OAR Box 1192

Prepped by Candice Davis

Document Number:

209) IV-D-58

Docket Number:

A-90-16

A-90-16
IV-D-58

ETHYL CORPORATION
GOVERNMENT RELATIONS
1155 Fifteenth Street, N.W., Suite 611
Washington, D.C. 20005
(202) 223-4411

Lt. Gen. Jeffrey G. Smith, U.S.A. (Ret.)
Director of Government Relations

23 July 1990

Mr. William K. Reilly
Administrator
The United States Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460

Re: Ethyl HiTEC® 3000, Docket A-90-16

Dear Mr. Reilly,

Transmitted herewith are comments in support of Ethyl Corporation's 9 May 1990 waiver request to use its fuel additive HiTEC® 3000. The comments address issues raised either during the 22 June 1990 public hearing on that request or comments received to date in the docket.

Ethyl anticipates commenting further, where appropriate, on any waiver-related comments, not presently in the docket, which are received by the EPA.

Jeffrey G. Smith

cc: Ms. Mary T. Smith
Director, Field Operations and Support Division (EN-397 F)
U.S. Environmental Protection Agency

July 23, 1990

ABSTRACT OF
COMMENTS IN SUPPORT OF THE WAIVER APPLICATION
FOR THE HITEC® 3000 PERFORMANCE ADDITIVE

Submitted by

Ethyl Corporation

Ethyl is seeking a waiver from the Environmental Protection Agency (EPA) to permit use of HiTEC® 3000 Performance Additive in unleaded gasoline in the United States. The manganese-based additive has been used for more than 10 years in gasoline in Canada and more than 20 years in leaded gasoline in the United States with no adverse impact on the environment or public health.

The Company's waiver application seeks use of one drop of the Additive in a gallon of gasoline. Any emissions of manganese would not discernibly change environmental levels in the air or soil.

Based on studies of the Additive's use in Canada, concentrations of airborne manganese are no different than those in countries where the Additive has not been used.

This supplemental filing by Ethyl follows a June 22 public hearing and responds to allegations and speculation, made both at the hearing and in comments submitted to the EPA, that use of the Additive would adversely affect human health and plug or otherwise harm catalytic converters. The filing also provides additional information regarding the Additive's ability to reduce the reactivity of hydrocarbon emissions.

Ethyl has satisfied the burden of proof stipulated by the Clean Air Act for those applying for fuel additive waivers by demonstrating through its extensive test program that the Additive would neither cause nor contribute to failures of emission control systems or an inability to meet emissions standards. Recognizing that the overall purpose of the Clean Air Act is to promote public health and welfare, Ethyl has also presented ample information to enable the EPA to judge the public health aspects of the Additive's use.

The use of the Additive would reduce significantly emissions of nitrogen oxides (NOx), carbon monoxide (CO), reactive hydrocarbons (HC) and aromatics, such as benzene, while causing no discernible change in environmental levels of manganese, the 12th most abundant element in nature.

Ethyl points out that the limited number of claims alleging possible adverse public health effects made in this proceeding (1) do not dispute that the Additive would cause significant reductions in emissions of numerous pollutants, and (2) ignore that manganese is a nutritionally essential element present in abundance in nature. Indeed, the normal daily intake of manganese is thousands of times greater than the maximum contribution of the Additive.

These are the facts:

- The maximum intake of manganese after 70 years of use of the Additive would be less than two micrograms per day (ingestion and inhalation) compared to intake from one daily multivitamin tablet (1,000-10,000 micrograms), one cup of tea containing (1,200 micrograms) or a slice of whole wheat bread (334 micrograms).

- The cumulative concentration of manganese in soil at a point 5 meters from a busy expressway caused by 50 years of use of the Additive would be less than the concentration caused by spilling one cup of tea, one time, at that point (4.6 versus 6.9 parts per million).

- After 50 years of use, the cumulative contribution of the Additive to manganese concentrations in soil five meters from a busy expressway would be the same as that resulting from watering one's lawn once per year (with a normal watering rate of one inch) during this period.

Six independent government reviews, including one made and one commissioned by the EPA, conclude that low level manganese emissions, such as those that would stem from use of the Additive, would not present any public health concern.

Ethyl also presents a recent review and assessment of the health literature on manganese by Roth Associates, a firm staffed by experts in toxicology and epidemiology who have served on EPA scientific advisory panels, plus independent assessments by Dr. Henry Wisniewski, a neuropathologist and Director of the Institute for Basic Research of the New York Department of Health; Dr. Robert Lauwerys, Director and Professor of Industrial Toxicology and Occupational Health at University of Louvain, Brussels; and Dr. W. Clark Cooper, former Medical Director of the U.S. Public Health Service.

The conclusions of these independent reviewers are best summarized by the Roth Associates report:

A-90-16

IV-D-58

BEFORE THE
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

IN RE APPLICATION FOR A FUEL ADDITIVE WAIVER FILED BY ETHYL CORPORATION UNDER § 211(f)(4) OF THE CLEAN AIR ACT	)))))))

COMMENTS IN SUPPORT OF THE WAIVER APPLICATION FOR THE HITEC® 3000 PERFORMANCE ADDITIVE

Submitted by:

ETHYL CORPORATION
P.O. BOX 2189
RICHMOND, VA 23217

Of Counsel:

Hunton & Williams
2000 Pennsylvania Ave., N.W.
P.O. Box 19230
Washington, D.C. 20036
(202) 955-1500

Ray Wilkins, Jr.
Senior Vice President
Ethyl Corporation
P.O. Box 2189
Richmond, VA 23217

July 23, 1990

SUMMARY

On May 9, 1990, Ethyl Corporation ("Ethyl") filed a fuel additive waiver application under § 211(f)(4) of the Clean Air Act ("CAA" or "Act"), for use of the HiTEC® 3000 Performance Additive (the "Additive") at a concentration of 0.03125 grams of manganese per gallon in unleaded gasoline. Since submittal of the waiver application, a limited number of comments have been filed with the Environmental Protection Agency ("EPA" or "Agency") suggesting that use of the Additive could have public health implications. This document and its appendices address the health issue in detail. In particular, they show that use of the Additive would cause <u>significant</u> <u>reductions</u> in emissions of nitrogen oxides (NOx), carbon monoxide (CO), reactive hydrocarbons (HC), formaldehyde and aromatics, such as benzene, while causing <u>no</u> <u>discernable</u> change in environmental loadings of manganese.

These comments also supplement the material presented in Ethyl's waiver application showing that the Additive (1) would reduce NOx and CO emissions, while having no practical effect on HC emissions; (2) would not cause catalyst plugging; (3) would be fully compatible with reformulated fuels; (4) would complement the use of oxygenates; and (5) would not adversely affect compliance with more stringent mobile source standards.

I. <u>USE OF THE ADDITIVE WILL PROMOTE THE PUBLIC HEALTH AND WELFARE, AND THE PRODUCTIVE CAPACITY OF THE NATION.</u>

The principal showing required of a waiver applicant under § 211(f)(4) of the Act is that an additive "not cause or contribute to a failure of any emission control device or system . . . to achieve compliance . . . with the emission standards" for which automobiles are certified. As described in its waiver application, Ethyl has met this requirement by conducting the most comprehensive fuel additive test program ever undertaken by a waiver applicant. To date, no commentator has submitted any analyses or new data refuting this conclusion.

In contrast to the "cause or contribute" standard, neither § 211(f)(4) of the Act nor its legislative history mention public health. Indeed, EPA itself has said that while emissions "of unregulated pollutants are of continuing interest to EPA [under other provisions of the Act] due to their potential adverse effect on health . . . [such considerations] <u>have no bearing on . . . [a] waiver decision</u>."[1/]

However, even though public health is not relevant to § 211(f)(4) considerations, Ethyl addressed at length the public health effects of use of the Additive[2/] to establish that approval of its application would promote the overall objectives

---

[1/] In Re Application for MTBE, Decision of the Administrator at 4, n.5 (December 26, 1978) (emphasis added).

[2/] <u>See</u> Ethyl Waiver Application at 60-69, and Appendices 7 & 8.

of the Clean Air Act.[3/] Ethyl showed that widespread use of the Additive would reduce emissions of noxious pollutants by up to 1.7 billion pounds per year, while not materially changing environmental levels of manganese. With respect to manganese specifically, the waiver application showed that the metal is nutritionally essential and has been extensively studied by EPA and other independent scientific bodies, all of which concluded that manganese emissions of orders of magnitude higher than those associated with use of the Additive would not cause adverse public health effects.[4/]

Because Ethyl has presented a sound basis for the Agency to exercise its judgment regarding any public health concerns, the burden is on those who advocate disapproval of the application on health grounds to come forward with evidence addressing the levels of manganese associated with HiTEC 3000 to support their claims. Significantly, no one has disputed that public health benefits would flow from the reductions in NOx, CO, reactive HC, benzene, and formaldehyde emissions associated with use of the Additive. Rather, those who have commented critically on the public health issue have speculated or presented unsubstantiated allegations that adverse effects would occur at environmental levels of manganese which differ insignificantly from those that occur in the natural environment.

[3/] The overall purpose of the Clean Air Act is "to promote the public health and welfare and the productive capacity" of the Nation's population. CAA § 101(b)(1).

[4/] <u>See</u> Ethyl Waiver Application at 62-69, and Appendix 8.

As discussed below, a large body of evidence supports the conclusions of EPA and other independent organizations that low levels of manganese present no public health concern.

A. Emissions and Ambient <u>Concentrations of Manganese</u>

Under Ethyl's waiver application, only one drop of the Additive (0.03125 grams) would be used in a gallon of gasoline. Manganese emissions would be extremely small. Based on data developed using EPA's Federal Test Procedure ("FTP") for particulate matter emissions from light duty diesel vehicles, a typical car would emit no more than 0.5 percent of the manganese contained in the Additive, approximately 0.06 grams of manganese annually. Assuming, as a margin of safety, that 30 percent of the manganese burned in the fuel were emitted (as was the case in Ethyl tests of the Additive in older, non-catalyst vehicles), only 3.6 grams would be emitted annually by a typical car.

Even at an emission rate of 30 percent, manganese emissions associated with widespread use of the Additive would amount to little more than one percent of the manganese emitted annually from <u>natural</u> <u>sources</u> (e.g., windblown dust).

1. <u>Manganese in the air</u>

Given the extremely low manganese emissions associated with use of the Additive, concentrations of airborne manganese would not materially differ from current naturally occurring levels. Consider the following:

- Actual monitored concentrations of manganese in Canada, where the Additive has been used for a decade at twice the amount sought in this application, range up to approximately 0.04 ug/m^3 in large urban areas. These concentrations are little or no different from those in the United Kingdom, where the Additive has never been used in gasoline.

- In the United States, the Additive has been used for over two decades in leaded gasoline. Manganese emissions from such use peaked in the mid-1980s. Actual mid-1980s monitored urban ambient concentrations, however, were only about 0.03-0.05 ug/m^3, again little different than in a country where the Additive has not been used.[5/]

- Actual ambient monitoring data in California in the mid-1980s in areas with high concentrations of mobile source traffic showed ambient manganese concentrations of about 0.015-0.03 ug/m^3. The mobile source contribution to these levels, which was estimated based on use of the Additive at levels much higher than proposed in this application, was only about 0.003-0.013 ug/m^3.

Thus, actual experience shows that the Additive would not discernibly contribute to airborne levels of manganese. Further confirmation is provided by conservative atmospheric modeling, which indicates maximum increases in urban ambient concentrations with use of the Additive in <u>all</u> new cars would be at most approximately 0.017 ug/m^3, even if one assumes that at least 30 percent of the Additive is emitted to the air.

2. <u>Manganese in the soil</u>

Manganese is the twelfth most abundant element in nature. The concentration of manganese in soil ranges up to 7,000 ppm, with an average of about 1,000 ppm. One cubic meter of soil contains on average approximately one kilogram of manganese. If

---

[5/] By comparison, total manganese emissions in 1999 resulting from the Additive's use would range down to 20 times <u>less</u> than the manganese emissions in the mid-1980s, based on Ethyl's particulate matter testing.

the Additive were used in all unleaded gasoline, the increase in soil concentrations 5 meters from a heavily travelled expressway would be only about 4.6 ppm after 50 years, even if one assumes that 30 percent of the manganese in the Additive is emitted. This is far less than one tenth of one percent of the average concentration of manganese naturally occurring in the soil (about 1,000 ppm).

Viewed another way, a uniform manganese contribution from the Additive of 4.6 ppm to the soil after 50 years would approximately equal the contribution made if one watered his lawn only once a year during this 50 year period (assuming a manganese concentration in water consistent with EPA's standard for drinking water, and a recommended watering rate of one inch). Indeed, the cumulative concentration of manganese in soil at a point five meters from a busy expressway caused by 50 years of use of the Additive would be less than the concentration caused by spilling a cup of tea, one time, at that point (4.6 ppm for soil versus 6.9 ppm for tea). Both comparisons assume that at least 30 percent of the manganese in the Additive is emitted.

Such comparisons (and many more) suggest that natural variation in the manganese content of soil would completely overwhelm any short term or cumulative contribution resulting from use of the Additive.

B. Population exposure to manganese

Health authorities recommend a normal daily intake of manganese of 2,000-5,000 ug, although higher levels are recommended for pregnant women, children, and the elderly. On a daily basis, an individual typically takes in 2,000-9,000 ug of manganese through ingestion of food and water, and about 0.8 ug through inhalation. About 120 ug of this typical daily intake is absorbed by the body, given the body's mechanism for regulating manganese uptake.

Exposure to manganese from use of the Additive would not, as a practical matter, change existing exposure levels. For example, assuming a worst-case mobile source contribution to ambient manganese concentrations based on actual monitoring data in California,[6/] SAI, Inc. calculated that the manganese accumulated at the soil's surface for over 70 years as a result of use of the Additive would increase the normal daily intake of manganese by less than one-tenth of one percent. That is, use of the Additive, even after 70 years, would contribute to an increase in manganese intake of less than 2 ug per day (inhalation and ingestion).

Based on the results of SAI's conservative exposure analysis, therefore, normal variations in daily intake of manganese (which range up to 7,000 ug per day) would be thousands of times greater than the maximum contribution of the Additive to

---

[6/] This assumption produces maximum ambient manganese concentrations due to use of the Additive essentially the same as those produced by the assumption that at least 30 percent of the manganese in the Additive is emitted.

manganese intake. An assumed maximum (worst case) manganese intake resulting from use of the Additive pales in comparison to:

- A multivitamin tablet (1,000-10,000 ug),
- An afternoon cup of tea (1,200 ug),
- A decision to eat a slice of whole wheat bread (334 ug) instead of white bread (164 ug), or
- Eating a banana (225 ug) instead of an apple (45 ug).

C. Impact of manganese on public health

Although neurotoxic effects are associated with exposures to manganese hundreds of thousand of times higher than maximum concentrations which would be caused by use of the Additive, manganese is still essential to human health. Such an anomaly is not unique to manganese. Other substances essential or beneficial to human health at relatively low levels (e.g., vitamin B-6) are neurotoxins at high exposure levels. The minute changes which the Additive would cause in current environmental levels of manganese would present no public health concern, a conclusion confirmed by numerous independent governmental reviews of the health implications of manganese emissions. For example,

- In 1985, EPA issued a final "Health Assessment Document for Manganese," and concluded that peak manganese concentrations as high as 125-250 ug/m^3 (concentrations higher than those at issue here by at least a factor of 10,000) would not "cause, or contribute to, air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious illness."
- In September 1988, the Health Effects Institute (HEI) completed another independent review of the health literature on manganese, and HEI concluded that no adverse health effects (neurological or respiratory) would occur even at manganese emission levels one

hundred times higher than those that would result from use of the Additive.

- Based on its review of the health effects of manganese, the Canadian Department of National Health and Welfare concluded in 1978 that "there is no evidence at present to indicate that expected ambient manganese concentrations [from automobile exhaust] would constitute a hazard to human health."

- In 1986, the Royal Society of Canada again reviewed the health literature and concluded that "the general public has a wide margin of health safety with respect to the worst case use of MMT in gasoline."

- In 1987, an official from Australia's Department of Health completed an independent evaluation of the public health effects of manganese, and concluded that "there is no toxicological evidence to suggest that the increased level of airborne Mn resulting from combustion of MMT as a petrol additive is likely to constitute a health risk to the general population."

- Based on its review of the literature, the World Health Organization has concluded that an annual average concentration of 1 ug/m^3 -- about ten to one hundred times higher than maximum urban ambient concentrations associated with use of the Additive -- "incorporates a sufficient margin of protection for the most sensitive population group."

To provide yet another independent scientific review of the health effects of manganese -- one which would incorporate studies performed since completion of the governmental reviews described above -- Ethyl retained Roth Associates, Inc. Dr. Roth and his colleagues (well-respected toxicologists and epidemiologists) have substantial experience regarding the public health impacts of various emissions, including manganese. They observed that:

- "Use of MMT [HiTEC® 3000] is unlikely to affect public health adversely. The anticipated increase of manganese in the environment from use of MMT is sufficiently small in comparison to the natural levels of this element and human intake of it that the body's ability to maintain consistent manganese levels should be unaffected. Indeed, manganese is necessary for proper functioning of the human body. Thus, no effect on health would be anticipated. Data concerning the impact of exposure to manganese at the levels anticipated to follow approval of MMT are limited, but they are consistent with the lack of any adverse health effect."

- "[N]one of the three major issues raised by commenters [NIEHS, EDF, Dr. Herbert Needleman, Dr. John Donaldson, Mr. Everett Hodges] on the Ethyl application is valid. First, manganese is very different from lead chemically, biologically, and environmentally. Thus, the experience with lead as a gasoline additive cannot be used as a model of what will happen if MMT is added to gasoline. Second, while high levels of manganese are associated with neurological effects, concern that exposure to the far lower manganese levels expected to result from MMT use has no basis. Finally, the concern that manganese is associated with violent criminal behavior is essentially speculation. The one study that directly supports it is seriously flawed."

- "[N]one of the other concerns raised by [the same] commenters provide a sound basis for concluding that the addition of MMT to gasoline as proposed by Ethyl would endanger public health."

Ethyl, as well, asked the views of three other acknowledged experts regarding the health effects of manganese. Their responses:

- Dr. Henry M. Wisniewski (neuropathologist, expert on aging process, Director of Institute for Basic Research of N.Y. Department of Health): "Ethyl provided enough evidence to show that adding manganese will not negatively affect human health and environment . . . There is no evidence to suggest that [neurotoxic] effects take place at lower Mn levels . . . [The evidence] is clearly in favor of approving Ethyl's application."

- Dr. Robert Lauwerys (Professor of Industrial Toxicology and Occupational Medicine, Director of the Unit of Industrial Toxicology and Occupational Health at University of Louvain, Brussels): [The World Health Organization's recommended guideline of 1 ug/m^3 average manganese exposure] "should incorporate a sufficient margin of protection for the most sensitive population group." (Note: The Additive would result in ambient manganese levels 10 to 100 times less than 1 ug/m^3.)

- Dr. W. Clark Cooper (former Medical Director of U.S. Public Health Service): Following a 1984 comprehensive review of then-existing literature on public health implications of manganese in the environment, he concluded that the "minute increments of Mn that would result from the use of MMT as a gasoline additive should not have any impact on the public's health." Following a recent review of available literature, he stated that "[A]s of July 1990, I am not aware of any new evidence to alter the conclusions [of the 1984 review]; if anything they have been strengthened."

In sum, and contrary to concerns or allegations expressed by a few of the commentators on Ethyl's waiver application, extensive studies and research have been made on the health effects of manganese. An informed body of opinion clearly agrees, without reservation, that the small levels of manganese emissions associated with use of the Additive would present no public health concern. The real public health effect of the Additive would be positive -- significant reductions in NOx, CO, reactive HC, benzene, and formaldehyde.

II. SUPPLEMENTAL INFORMATION CONFIRMS THAT THE ADDITIVE WILL NOT CAUSE OR CONTRIBUTE TO THE FAILURE OF EMISSION CONTROL DEVICES, AND THAT THE ADDITIVE IS AN ATTRACTIVE OPTION FOR POLLUTION CONTROL.

A. Use of the Additive Will Enhance Catalytic Efficiency Without Causing Plugging or Other Adverse Effects on Emission Control Systems.

In order to supplement the extensive test results in its waiver application, Ethyl is submitting herewith further information and enclosures on the Canadian experience regarding the effect of the Additive on catalysts. For example,

- The Royal Society of Canada concluded in 1986 that "in eight years of use of MMT in unleaded gasoline in Canada there does not appear to have been a higher incidence of catalytic converter failure than in the United States."

- The Canadian Government Specifications Board (CGSB) reported in 1986 that "use of MMT at current CGSB levels does not significantly compromise emission-control system operation or component durability."

- Both the Motor Vehicle Manufacturers Association and the Automobile Importers of Canada reported to the CGSB in 1986 "that manufacturers' Canadian warranty claims on emission components are comparable to the U.S.," where the Additive is not used in unleaded gasoline.

- Petro-Canada, Inc., an oil company wholly owned by the Canadian government, has reported in 1990 based on an ongoing investigation that "[w]e have not had a single complaint referencing catalyst plugging . . . . [O]ur research department has examined a number of catalysts from our high-mileage in house test fleet without finding evidence of catalyst plugging . . . . [A]uto manufacturers . . . have not submitted any evidence that MMT is associated with catalyst plugging."

The only study of which Ethyl is aware that suggests the Additive would cause catalyst plugging under normal driving conditions was outlined in a paper presented at an SAE meeting recently by Ford Motor Company. That study, however, is flawed in several critical respects, most notably because the catalyst conversion efficiencies reported by Ford <u>were based on laboratory methods for which no correlation with actual field emissions testing is shown</u>. By contrast, Ethyl's extensive test program demonstrated <u>in actual operations after 75,000 miles of vehicle operation (and beyond)</u> that use of the Additive did not adversely affect the catalyst, and in fact, improved the conversion efficiency for NOx emissions.

The record fully supports Ethyl's conclusion that the Additive will not cause catalyst plugging.

B. Effects of the Additive on NOx and CO Emissions

In response to questions raised at the public hearing, Ethyl contacted Dr. Roy Harrison, the Director of the Institute of Aerosol Science at the University of Essex in England, regarding the effects of the Additive on NOx and CO emissions. Based on his research addressing such effects, Dr. Harrison has offered comments (which are enclosed) explaining, from a theoretical standpoint, the reason significant reductions in NOx and CO emissions should be anticipated.

C. Compatibility of the Additive with Oxygenates

Ethyl is submitting herewith additional information showing that the Additive will complement the use of oxygenates, not replace them. With the anticipated limitations on the aromatic content of gasoline, both oxygenates and the Additive will be needed to provide required octane levels.

D. Compliance with More Stringent Mobile Source Standards

As Ethyl showed in its waiver application, use of the Additive would not adversely affect compliance with even tighter HC emission standards, as proposed in the pending Clean Air Act legislation. Indeed, Ethyl's supplemental analyses show that the reactivity of HC emissions would be significantly reduced with use of the Additive, and that catalytic converter efficiency would increase for CO and NOx while remaining constant for HC.

By replacing aromatics, improving overall converter efficiency, and reducing the reactivity of HC emissions, the Additive could assist in the attainment of future mobile source standards, including more stringent HC standards.

III. CONCLUSION

The information presented in Ethyl's waiver application, as supplemented by these comments, demonstrates that use of the Additive would not cause or contribute to the failure of emission control systems to meet applicable emission standards, and would promote the overall objectives of the Act. The Additive would provide a significant health benefit by substantially reducing mobile source emissions of pollution. It would not perceptibly change environmental loadings of manganese. It would pose no threat whatsoever to the public health of the nation. And it would reduce this nation's dependence on imported oil. For all of these reasons, this waiver application should be promptly approved.

TABLE OF CONTENTS

APPENDICES

I. INTRODUCTION

On May 9, 1990, Ethyl Corporation ("Ethyl") filed a fuel additive waiver application under § 211(f)(4) of the Clean Air Act ("CAA" or "Act") for use of the HiTEC® 3000 Performance Additive (the "Additive") at a concentration of 0.03125 grams manganese per gallon as the Additive in unleaded gasoline. On June 5, 1990, the Environmental Protection Agency ("EPA" or "Agency") published a notice in the Federal Register indicating that it intended to hold a public hearing on the waiver application and would accept comments on the waiver until July 22, 1990.[1/]

Since submittal of the waiver application, and at the public hearing, a limited number of comments have been submitted to the Agency concerning the waiver application. This submittal responds to those comments. If any additional questions are raised in comments received on or about July 23, 1990, Ethyl will respond to them as expeditiously as possible.

As noted in Ethyl's initial submission, the principal burden Ethyl must meet under CAA § 211(f)(4) is to show that use of the Additive will not cause or contribute to the failure of emission control systems to meet applicable emission standards. Ethyl believes that its comprehensive fuel additive test program and the materials presented in its waiver application satisfy this burden. To date, no commentator has submitted any analysis or new data refuting this conclusion.

[1/] 55 Fed. Reg. 22347 (June 5, 1990). Because July 22, 1990 falls on a Sunday, EPA informally indicated that they would accept as timely comments filed by July 23, 1990.

In addition, Ethyl provided in its waiver application information showing that approval of the application would further the general purposes of the Act -- i.e., that it would promote the "public health," the public "welfare," and the "productive capacity" of the nation. Ethyl did so by addressing, among other things, the overall impact of the Additive on exposure to emissions of both regulated pollutants (such as nitrogen oxides, carbon monoxide, hydrocarbons, and benzene) and manganese.

The initial submission showed that EPA and other independent scientific bodies have unanimously concluded that low levels of manganese emissions present no public health concern, and that the overall impact of the Additive on public health would be positive. Ethyl also showed that use of the Additive would promote the "productive capacity" of the nation.

Several commentators have now suggested that Ethyl has not provided enough information upon which to make a determination that use of the Additive will not adversely affect the public health. The principal focus of these supplemental comments is, therefore, on the public health implications associated with use of the Additive. These comments also briefly address several issues that have been raised in connection with the impact of the Additive on emission control devices.

II. THE HEALTH INFORMATION SUBMITTED BY ETHYL IN ITS WAIVER APPLICATION AND IN THESE SUPPLEMENTAL COMMENTS FULLY JUSTIFIES APPROVAL OF THE APPLICATION.

As noted above, several comments have been submitted to the Agency suggesting that Ethyl has not adequately addressed the public health implications of the Additive.[2/] None of these comments, however, contest that the Additive will benefit public health by reducing emissions of nitrogen oxide ("NOx") and carbon monoxide ("CO"), by reducing the reactivity of hydrocarbon ("HC") emissions, and by lowering emissions of other pollutants, such as benzene and formaldehyde.

Rather, these comments merely express a generalized concern that, since manganese is a neurotoxin at high exposure levels, the very small increases associated with use of the Additive (levels within the range of normal background concentrations) should be of public concern.[3/] These comments provide no evidence that any adverse effects in fact are likely to occur at low exposure levels. As a result, these comments do no more than (1) complain that Ethyl should provide more evidence that alleged health effects will not occur, and (2) argue that, in the absence of further evidence, the hypothetical health effects alleged

---

[2/] See, e.g., Transcript of Public Hearing on Ethyl Corporation Fuel Waiver Application, U.S. Environmental Protection Agency, pp. 6-15, 42-43 and 63-64 (June 22, 1990)[hereinafter "Transcript"].

[3/] See, e.g., id. at p. 7.

should be given more weight than the real benefits associated with use of the Additive.[4/]

As discussed above, these commentators have presented an alarmist's view of alleged potential health effects of manganese exposure which is inconsistent with the existing, extensive, and widely-accepted body of evidence addressing manganese. Moreover, they have simply ignored the real and significant public health benefits that would be associated with use of this Additive. As discussed below, since these commentators lack proof of the effects they allege, they improperly attempt to assign to Ethyl the burden of disproving their unfounded allegations. This is a burden not contemplated by CAA § 211(f)(4).[5/]

4/ See, e.g., id. at p. 17. It should be noted that these commentators are simply wrong when they state that Ethyl has made no attempt to address the public health effects of manganese. See, e.g., id. at pp. 64-65. Ethyl's waiver application and an appendix to the application both address this issue. See In Re Application for a Fuel Additive Waiver Filed by Ethyl Corporation Under § 211(f)(4) of the Clean Air Act (May 9, 1990)[hereinafter "Waiver Application"] at pp. 67-69, and Appendix 8 thereto. Ethyl did not feel it was necessary, however, to describe in detail the comprehensive reviews of the health implications of manganese already performed by EPA, the Canadian government, Australia, the World Health Organization and the Health Effects Institute. Moreover, contrary to the contentions of these commentators, Ethyl's waiver application and the materials on which it relies address the neurotoxic effects of manganese. See, e.g., Waiver Application, Appendix 8, at p. 11; Health Assessment Document for Manganese (hereinafter "HAD"), at 6-4 to 6-46. A copy of the HAD is provided in Appendix 3 as Attachment B-1.

5/ Indeed, the Agency itself acknowledges that Congress did not intend waiver applicants to bear the burden of proving "negative proposition[s]" under § 211(f)(4). See Waiver Application at p. 43, n. 100 and accompanying text.

A. The Statutory Standard

The statutory standard for judging fuel additive waiver applications under the Act does not specifically address the public health-related implications of use of a new additive. Section 211(f)(4) of the Act provides only that an applicant for a fuel additive waiver must show that the additive

> will not cause or contribute to a failure of any emission control device or system (over the useful life of any vehicle in which such device or system is used) to achieve compliance by the vehicle with the emission standards with respect to which it has been certified.[6/]

There is nothing in the relevant statutory language which refers directly to public health and welfare.

Nor, for that matter, does the legislative history of § 211(f) identify health as a relevant criterion. The legislative history makes clear that Congress was concerned primarily with the impact of new fuel additives on emission control systems. One congressional report on the 1977 Amendments to the Act indicates, for example, that Congress enacted § 211(f) "to prevent the untested use of additives with cavalier disregard for harmful effects on emission control systems and devices."[7/] Similarly, another report indicates that § 211(f) was enacted because "emission systems currently in use could not be

---

6/ 42 U.S.C. § 7545(f)(4).

7/ A Legislative History of the Clean Air Act Amendments of 1977, Comm. Print, Senate Comm. on Env't and Public Works 1978)(Serial No. 95-16), at 362 (hereinafter "1977 Legis. Hist.").

adequately protected from possible deterioration" due to the use of new additives by then-existing law.[8/] Indeed, the only reference to public health in the legislative history of § 211(f) makes clear that Congress did not intend that the Agency's decisions under § 211(f)(4) be governed by health-related issues.[9/]

This interpretation of § 211(f) has been adopted by the Agency in prior waiver application decisions. In one of EPA's first decisions under § 211(f)(4), the Petro-Tex Chemical Corporation requested a waiver for the use of MTBE in unleaded gasoline. In denying the waiver application on the basis of an insufficient record regarding MTBE's impact on evaporative and exhaust emissions, EPA noted that:

> Aldehyde emissions have been widely discussed in connection with the use of oxygenated fuels. Although emissions of aldehyde, and other unregulated pollutants are of continuing interest to EPA due to their potential adverse effect on health, they have

---

[8/] Id. at 1464 (emphasis added).

[9/] "The committee expects the Administrator to require manufacturers to test registered additives insofar as they affect health and public welfare under sections (a), (b) and (c) of this section." 1977 Legis. Hist. at 1466 (emphasis added). These other provisions of § 211 therefore are to be the principal vehicle for considering public health concerns with respect to fuel additives.

In this regard, it should be noted that the Additive has been a registered fuel additive since the early-1970s. No one has raised any public health concern with respect to use of this Additive under any of these other provisions of the Act. Similarly, no one has ever challenged EPA's final determination under § 112 of the Act that manganese cannot be reasonably anticipated to cause or to contribute to serious health effects. See infra pp. 11-12.

> <u>no bearing on this waiver decision. The waiver provision, section 211(f)(4), is solely concerned with the emission standards which apply to tailpipe emissions of HC, CO, and NOx and evaporative HC emissions.</u>[10/]

This interpretation of § 211(f)(4) is also reflected in the Agency's waiver application guidelines. These guidelines describe the information that a fuel additive waiver applicant must submit to the Agency for its review. While the guidelines direct the applicant to submit, among other things, "data relating to a fuel additive's emissions effects which are derived from vehicle testing," they make no reference to information on the potential public health implications of a new Additive.[11/]

While § 211(f)(4) does not require the Agency to address public health, however, this does not mean that public health has no relevance to a waiver proceeding. When it amended the Act in 1970, Congress stated that the overall goal of the Act is "to protect and enhance the quality of the Nation's air" in a way that "promote[s] the public health and welfare and the productive capacity of its population."[12/] As the Agency has recognized, a "<u>balancing of the social and economic considerations with the environmental implications [of a decision is necessary] . . . to fulfill the mandate of the Clean Air Act</u> to 'protect and enhance

---

[10/] In Re Application for MTBE, Decision of the Administrator (December 26, 1978) at 4, n. 5. EPA also indicated that "[n]otwithstanding section 211(f), EPA retains authority to regulate any fuel or fuel additive <u>under section 211(c)</u> of the Act." <u>Id.</u> (Emphasis added).

[11/] <u>See</u> 43 Fed. Reg. 11258 (1978).

[12/] <u>See</u> 42 U.S.C. § 7401(b)(1).

the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population.'"[13/] The courts have expressly recognized that the mobile source provisions of Title II should be implemented in light of these broader goals of the Act.[14/]

While the applicant clearly has a special burden under § 211(f)(4) to meet the "cause or contribute" standard with respect to emission control devices, nothing in the statutory language or legislative history of this provision extends this special burden to other issues, such as public health considerations, made relevant by the general purposes clause of the Act.[15/] As a result, the only "burden" Ethyl must carry concerning the Additive's impact on public health is the burden of coming forward with sufficient information for the Agency to exercise a reasoned judgment regarding the overall health effects of the Additive.[16/]

13/ 39 Fed. Reg. 31000, col. 1 (1974) (emphasis added).

14/ In Chrysler Corp. v. U.S. Environmental Protection Agency, 631 F.2d 865, 888 (D.C. Cir. 1980), for example, the court refused to interpret the automotive recall provision of section 207 of the Act "in a manner which runs counter to the broad goals which Congress intended it to effectuate." The court acknowledged that the "broad purpose of the Clean Air Act Amendments of 1970 is plain: 'to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population[.]'" Chrysler Corp., 631 F.2d at 888. See also General Motors Corp. v. Ruckelshaus, 742 F.2d 1561, 1572 n.15 (D.C. Cir. 1984).

15/ See supra note 6, and pp. 5-7.

16/ Where Congress made public health considerations a principal factor in regulatory decisions regarding fuel additives, Congress (continued...)

B. Ethyl Has Satisfied the Statutory Standard.

Given the overall purposes of the Act, Ethyl specifically addressed in its waiver application the implications of the use of the Additive for public health and welfare, and for the productive capacity of the Nation. On the public health issue, for example, Ethyl presented information on the public health effects of manganese, citing, among other things, the results of studies conducted by the United States and other governments regarding the effects of manganese in the environment. At the same time, Ethyl showed that the substantial reduction in overall automotive tailpipe emissions associated with use of the Additive

---

16/ (...continued)
placed an affirmative burden on the Agency to determine based on available evidence that an additive will adversely affect the public health. CAA § 211(c). Section 211(c)(1) of the Act provides, in pertinent part, that:

> The Administrator may, from time to time . . . by regulation, control or prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel or fuel additive for use in a motor vehicle engine (A) if in the judgment of the Administrator any emission product of such fuel or fuel additive causes, or contributes, to air pollution which may reasonably be anticipated to endanger public health or welfare . . . . 42 U.S.C. § 7545(c)(1).

Under the terms of this provision, the Agency is "free to regulate . . . [a] fuel additive under section 211" only after it considers "all relevant medical and scientific evidence available," id. at § 7545(c)(2)(A), and then determines that the additive "may reasonably be anticipated to endanger public health and welfare." See, e.g., Ethyl Corp. v. EPA, 541 F.2d 1, 11-33 (D.C. Cir.), cert. denied, 426 U.S. 941 (1976); Amoco Oil Co. V. EPA, 501 F.2d 722 (D.C. Cir. 1974).

will have a direct beneficial effect on public health.[17] As discussed below, this information is more than sufficient to establish a prima facie case that exposure to the small additional amounts of manganese resulting from use of the Additive will not adversely affect the public health or welfare.[18]

Nevertheless, Ethyl has assembled in these comments a large amount of additional scientific information expanding upon, and confirming, that no public health concern is presented by the low level manganese emissions here at issue. This information evidences the broad consensus of the scientific community that low level manganese emissions present no public health concern, and shows that these emissions provide no basis for denying Ethyl's waiver application.[19]

Having presented a basis for the Agency to exercise its judgment on the safety of manganese, the burden on the health issue must shift to the limited number of commentators who allege that use of the Additive will result in emissions harmful to the public health and welfare. These claimants must provide scientifically sound evidence showing that manganese at low levels is associated with the public health concerns they allege. No such showing has been made with respect to manganese, and no

---

17/ See Waiver Application, at pp. 62-67.

18/ Indeed, the Agency has found these data on manganese adequate in the past to exercise its judgment regarding public health effects. See infra note 78, and accompanying text.

19/ See infra pp. 32-44.

attempt has been made to dispute the other significant public health benefits associated with use of the Additive.[20]

Finally, the Administrator has already considered much of the same underlying information on manganese and public health in his recent determination that manganese does <u>not</u> warrant regulation as a hazardous air pollutant under § 112 of the Act.[21] This determination means that the Agency <u>has already concluded</u> that current levels of manganese in the environment -- levels which are in some cases many orders of magnitude higher (particularly around point sources) than those that would result from use of the Additive -- will not "cause[], or contribute[] to, air pollution which may reasonably be anticipated to result in an increase" in death or serious injury.[22] Given this final regulatory determination on the public health implications of exposure to low levels of manganese in the environment (a final decision that was not challenged by any party), those who oppose the waiver application on public health grounds have the added burden of explaining why the Agency's recent decision on

---

20/ <u>See infra</u> pp. 13-19.

21/ <u>See</u> 50 Fed. Reg. 32627 (1985).

22/ <u>Id.</u> at 32628, col. 2. The statutory standard under § 112 is very similar to the standard under which the Administrator has explicit authority to address the health implications of fuel additives (i.e., CAA § 211(c)). <u>See supra</u> note 16.

manganese is no longer valid or relevant to a decision on Ethyl's waiver application.[23/]

In sum, Ethyl has established that use of the Additive will result in a net benefit to public health. No one has provided any specific evidence to rebut this case. In light of the full administrative record on this issue, the waiver application must be granted.

III. USE OF THE ADDITIVE WILL HAVE A BENEFICIAL EFFECT ON PUBLIC HEALTH AND WELFARE, AND ON THE PRODUCTIVE CAPACITY OF THE NATION.

Approval of the Additive for use in unleaded gasoline will further the overall objectives of the Act. From a public health standpoint, use of the Additive will (1) reduce total automotive tailpipe emissions; (2) reduce refinery emissions; (3) have a beneficial effect on ambient concentrations of benzene, formaldehyde, and other noxious pollutants, and potentially reduce ambient ozone concentrations; and (4) achieve these beneficial effects without significantly increasing environmental levels of manganese, even under "worst-case" assumptions. From the standpoint of the nation's productive capacity, use of the Additive will extend the nation's existing oil supplies, reduce the nation's dependence on imported oil, and reduce the balance of trade deficit. The sections that follow summarize the

---

[23/] Significantly, one of the commentators opposed to the Additive, Ms. Silbergeld, was a reviewer of EPA's HAD, on which this final regulatory decision under § 112 of the Act was based. Ms. Silbergeld therefore was aware of both the contents of the HAD and of the Agency's final regulatory decision based on that document. She did not, however, choose to challenge that decision.

benefits associated with use of the Additive, and respond to specific comments and questions regarding this aspect of Ethyl's waiver application.

A. Use of the Additive Reduces Emissions of Criteria and Other Pollutants.

The most significant benefit associated with use of the Additive is that it reduces overall emissions of criteria and other pollutants. Based on Ethyl's extensive test data (accumulated over 75,000 miles of vehicle operation), overall tailpipe emissions from cars using the Additive were, on average, 0.32 grams per mile less than the overall emissions from cars using clear fuel.[24/]

In addition, because use of the Additive will allow refiners to reduce the severity of the refining process, refinery emissions would be reduced.[25/] As a result of these emission reductions, Ethyl estimates that by 1999, use of the Additive would reduce total pollutant emissions from automobiles and refineries by approximately 1.7 billion pounds annually.[26/] This estimated reduction in pollutant emissions is summarized below:

24/ Waiver Application, Appendix 2A, at pp. D-25 to D-27.

25/ Id., Appendix 6, at p. 2.

26/ Id., Appendix 7.

TOTAL POLLUTANT REDUCTION

Use of the HiTEC 3000 Performance Additive (pounds per year)

Pollutant	1999
Nitrogen oxide	644,000,000
Carbon Monoxide	988,000,000
Hydrocarbons[27]	0
Particulates	1,100,000
Sulfur Oxides	150,000
Aromatics	35,200,000
Formaldehyde	3,500,000
Total	**1,671,950,000**

These reductions in pollutant emissions will have a correspondingly beneficial effect on ambient concentrations of several pollutants which have serious public health implications. For example, use of the Additive could marginally reduce peak ambient ozone concentrations, as well as population exposure to ozone.[28] Similarly, use of the Additive would reduce tailpipe emissions of several potent carcinogens, such as benzene and formaldehyde. Ambient benzene concentrations alone could reasonably be expected to drop by three to ten percent.[29]

27/ While the cars in Ethyl's test fleet exhibited a slight increase in hydrocarbon ("HC") emissions, Ethyl has not included the small HC increase in the listing above because, among other things, use of the Additive will allow refiners to reduce the aromatic content of unleaded gasoline which would have the effect of reducing HC emissions. See id. at 1. Moreover, as is discussed further below, use of the Additive could significantly reduce the reactivity of HC emissions. This is an additional emissions benefit not incorporated in the Table presented above.

28/ See Waiver Application, Appendix 5, at pp. 52-63.

29/ Id. at p. 65.

Ambient concentrations of formaldehyde could be expected to fall as well.[30]

The reductions in emissions of pollutants such as NOx, benzene and formaldehyde would occur with each and every gallon of gasoline consumed that contains the Additive. As a result, the public would experience a significant, continuing, and cumulative health benefit over time from the use of the Additive.

Moreover, as noted in Ethyl's initial waiver submission, the Additive's beneficial effects would occur without increasing automotive hydrocarbon emissions in a meaningful way.[31] While hydrocarbon emissions increased slightly in Ethyl's test program, Ethyl showed through detailed statistical analysis that this increase was so slight that it would not cause or contribute to the failure of vehicles to meet the hydrocarbon emission standard.[32] Moreover, this increase should not occur in actual commercial operation because refiners will take advantage of the Additive's octane boosting properties and lower the aromatic content of gasoline, as stated by numerous comments submitted to

---

30/ Reductions of benzene and formaldehyde are a specific goal of proposed § 207 of H.R. 3030. See House Rep. No. 101-490, Part I, 101st Cong., 2nd Sess. 305 (1990)("the regulations [to control the emission of hazardous emissions from mobile sources] must apply, at a minimum, to benzene and formaldehyde").

31/ See Waiver Application, Appendix 10.

32/ Waiver Application, Appendices 2A and 2B.

the Agency.[33/] This, in turn, would tend to offset the small hydrocarbon increase observed during Ethyl's test program.[34/]

Furthermore, additional analysis of the tailpipe speciation data developed by Ethyl during its test program suggests that even if the Additive were to result in slightly higher hydrocarbon emissions, <u>the reactivity of the hydrocarbon emissions would be substantially less for Additive-fueled vehicles</u>.[35/] "Reactivity" is important because it is a measure of the ozone-forming potential of specific hydrocarbon emissions.

Briefly, this reactivity analysis shows that when various fuels of equal octane are compared in two test vehicles -- one

---

33/ In a letter to the docket, <u>Clark Oil and Refining Corporation</u> indicated, for example, that "the aromatic concentration in the gasoline would be reduced by <u>2-4%</u>" if the Agency approves use of the Additive. Letter to William Reilly from Ralph S. Cunningham dated June 6, 1990 (docket entry IV-D-03) (emphasis added). Similarly, <u>Fletcher Oil and Refining Company</u> has concluded that use of the Additive "will reduce benzene and aromatics in gasoline." Letter to Docket A-90-16 from James Lopeman dated June 11, 1990 (docket entry IV-D-07). This view is also shared by <u>ARCO Products Company</u>. <u>See</u> Letter to Air Docket from D.H. Smith dated June 22, 1990 (docket entry IV-D-08) ("refiners will be able to reduce high octane aromatics with HiTec 3000 thereby reducing the reactivity of the exhaust"). <u>See also</u> Letter to Mary Smith from Robert Haugen, President, Howell Hydrocarbons dated June 13, 1990 (docket entry IV-D-10) ("HiTEC 3000 would allow our company to reduce the amount of aromatics in our gasoline."); Letter to Air Docket from Joel Wilkinson, Vice President, The Louisiana Land and Exploration Company dated June 25, 1990 (docket entry IV-D-13) ("use of MMT . . . would allow us to reduce . . . overall aromatics in the gasoline").

34/ <u>See</u> Waiver Application, Appendix 10, at pp. 3-6.

35/ <u>See</u> Ethyl Corporation's Comments in Support of the Waiver Application for the HiTEC® 3000 Performance Additive, Appendix 1 [hereinafter cited as "Appendix __"]. For a more detailed description of the speciation analysis, <u>see</u> Waiver Application, Appendix 4.

fueled on gasoline containing the Additive and one fueled on gasoline containing a small additional amount of the aromatic xylene to equalize fuel octane -- the total reactivity of the hydrocarbon emissions from the Additive-fueled vehicle fell for all of the fuels tested.[36] The results of this analysis provide yet an additional indication why the small increase in hydrocarbon emissions exhibited in the Additive-fueled vehicles in Ethyl's test program is not important as a practical matter.[37]

Finally, because of these substantial reductions in pollutant emissions, use of the Additive will result in significant benefits to public health. The substantial reduction in NOx emissions and the reduction in the reactivity of hydrocarbon emissions should contribute to reduced ambient ozone concentrations -- a pollutant that has been linked with eye

---

[36] Appendix 1. The speciation testing included three different fuels: a certification fuel (Howell EEE), a commercial fuel (Texaco) and a reformulated fuel (EC-1). The decreases in reactivity for Additive-fueled emissions ranged from 19 to 31 percent. Appendix 1, at Attachment 2. Moreover, to obtain an independent assessment of this reactivity analysis, Ethyl requested Mr. Fred Lurmann, a recognized expert on this issue, to provide his expert opinion of the analysis. Mr. Lurmann indicated that Ethyl had "used the best available reactivity scale for assessing the effect of this additive on reactivity. Based on the results of this two car test, the additive appears to substantially reduce the photochemical reactivity for all of the base fuels." See Appendix 1, Attachment 4, at pp. 3-4. For this reason, Mr. Lurmann concluded that "widespread use [of the Additive] would have beneficial effects on ambient ozone concentrations." Id. at p. 4. Mr. Lurmann also noted that the reactivity analysis was consistent with techniques currently being considered by the California Air Resources Board for evaluating the reactivity of hydrocarbon emissions. Id. at p. 3.

[37] A detailed discussion of the materiality of the slight hydrocarbon emission increase is provided in the Waiver Application at pp. 46-56, and Appendix 10 thereto.

irritation, cough and chest discomfort, headaches, upper respiratory illness, increased asthma attacks, and reduced pulmonary function.[38/]

Reductions in carbon monoxide emissions would help to limit exposure to excessive concentrations of a pollutant that "in combination with underlying heart disease or other cardiovascular risk factors could be responsible for a very large number of preventable deaths."[39/] Similarly, reductions in formaldehyde, and aromatics such as benzene, associated with use of the Additive has the potential to reduce the estimated 400 to 1850 cancer cases caused each year by noxious pollutants emitted from mobile sources.[40/]

38/ Walsh, Michael P., Pollution on Wheels: The Need for More Stringent Controls on Hydrocarbons and Nitrogen Oxides to Attain Healthy Air Quality Levels Across the United States, American Lung Association (February 11, 1988), at 13-18. Similarly, exposure to elevated NO2 concentrations has by itself been linked with

> increased susceptibility to respiratory infection, increased airway resistance in asthmatics, and decreased pulmonary function . . . and respiratory problems in school children -- cough, runny nose and sore throat are among the most common -- as well as increased sensitivity to bronchoconstrictors by asthmatics.

Id. at 21.

39/ Id. at 19 (emphasis added)(citing Stern, Frank B, et al., Heart Disease Mortality Among Bridge and Tunnel Officers Exposed to Vehicular Exhaust, NIOSH).

40/ Id. at 20. For a general discussion of the health benefits associated with a reduction in emissions of NOx, CO, benzene and other pollutants, see Appendix 3, at E-1 to E-5.

In sum, Ethyl's extensive test program has established that reductions in emissions of these pollutants will occur, and will continue to occur as long as the Additive is used in gasoline. For this reasons, use of the Additive will have a clear, cumulative, and positive impact on public health.

B. While Reducing Emissions of Numerous Noxious Pollutants, Use of the Additive Will Not Significantly Change Existing Levels of Manganese Exposure -- Levels that EPA and Other Independent Organizations Have Concluded Present No Public Health Concern.

The amount of manganese emitted to the environment by automobiles using the Additive would be very small -- so small, in fact, that the levels of manganese already in the environment would not significantly change. EPA and other independent organizations have concluded that these levels of manganese (including levels which are in some cases orders of magnitude higher than those which would exist even if the Additive was used in all gasoline) do not present a public health concern.[41/]

1. Manganese emissions resulting from use of the Additive.

In its waiver application, Ethyl reported that only about 0.5 percent of the manganese in the Additive was emitted from the tailpipe of several of the cars used in Ethyl's test program.[42/] This information is based on the particulate matter test developed by EPA to measure compliance by diesel-fueled vehicles

---

[41/] See infra pp. 32-37.

[42/] Waiver Application, Appendix 3, at pp. 15-16.

with particulate standards under the Act.[43/] The test is a recognized part of the Federal Test Procedure (FTP) for light-duty diesel vehicles, and was designed to insure that diesel exhaust "is in a state of equilibrium with the surrounding air similar to what would be encountered in actual road use."[44/]

Based on the results of the FTP particulate testing, the amount of manganese emitted from the tailpipe would be very small. Over the course of 100,000 miles of vehicle operation, for example, a typical automobile would emit only about one-half of one gram of manganese. On an annual basis, a typical car would emit only about 0.06 grams of manganese.[45/]

[43/] See 40 CFR §§ 86.110-82, 86.111-82, and 86.112-82.

[44/] 45 Fed. Reg. 14496, 14509 (1980). The particulate tests were conducted on all cars (3 clear and 3 HiTEC 3000) from three of the eight models used in the test fleet. The measured emissions were consistent from model to model and from car to car within models. The average amount of manganese emitted was 0.39 percent of the manganese consumed in the fuel. The tests were conducted using the standard EPA FTP emissions test cycle. See Waiver Application, Appendix 3, at pp. 15-16. The particulate measurement system is designed such that the air velocity within the test tunnel would assure that particulate matter below approximately 50 micrometers would be airborne and collected in the sampling setup.

[45/] See Waiver Application, Appendix 8, at 6. As Ethyl has noted, the primary form of the manganese emitted from the tailpipe of cars using the Additive is Mn_3O_4, with some traces of Mn_2O_3 and MnO. See G.L. Ter Haar, M.E. Griffing, M. Brandt, D.G. Oberding, M. Kapon, "Methylcyclopentadienyl Manganese Tricarbonyl as an Antiknock: Composition and Fate of Manganese Exhaust Products," J. Air Pollution Control, 25 (1975) 858-860 [hereinafter "Manganese Exhaust Products"]; K. Otto, R.J. Sulak, Environ Sci. Technol., 12, 181-84 (1978); H.W. Edwards, R.M. Harrison, Catalysis of NO Decomposition by Mn_3O_4, Environ Science & Tech. 673-76 (1979). Manganese is present in the environment in many chemical forms, including those at issue here. Moreover, the mass median equivalent diameter (MMED) of the airborne

(continued...)

In order to be conservative in this analysis, however, Ethyl has also assumed that manganese emissions that result from use of the Additive could range up to 30 percent of the manganese in the Additive. This estimate is based on testing conducted in the mid-1970s on older cars (i.e., those without any catalytic converters), using an urban driving cycle.[46/]

[45/] (...continued)
manganese emission has a size of approximately 0.3 micrometers. See Manganese Exhaust Products, supra. Once the Mn_3O_4 falls to the soil, it quickly becomes indistinguishable from the manganese already present in the soil, since manganese compounds are readily converted in the environment. See Appendix 2, Attachment 2. In addition, manganese in the environment, and particularly in the soil, may change valence depending on soil pH and microbial action. See HAD, supra note 4, at 3-56 to 3-60.

[46/] Manganese Exhaust Products, supra note 45. The results of this testing were based on application of the Federal Test Procedure ("FTP"). Id.

The assumption that 30 percent of the manganese in the Additive is emitted provides a conservative assessment for several reasons. First, as noted, it is based on testing of older vehicles without catalytic converters, or other engine design changes which have dramatically improved the fuel combustion efficiencies (and reduced particulate matter emissions) of automobiles. See e.g., K. Habibi, et al., "Characterization and Control of Gaseous and Particulate Exhaust Emissions from Vehicles," Air Pollution Control Assoc., Fifth Technical Meeting (October 1970)(total particulate emissions from a 1960s unleaded vehicles were 0.15 grams per mile, a level more than 20 times higher than the average particulate emissions from clear cars in Ethyl's test fleet). Moreover, those cars not equipped with catalysts which still operate today represent a sharply declining share of vehicles currently on the road. See Waiver Application, Appendix 7.

While some have suggested that Ethyl should perform a material balance to determine how much of the manganese in the Additive is emitted from the tailpipe, a material balance in this case would be difficult to perform and fraught with uncertainty. For example, the goal of this analysis would be to account for all of an extremely small amount of material (only about 90 grams if all of the manganese in the Additive remained in the test
(continued...)

Whether one assumes that manganese is emitted at either the 0.5 percent or 30 percent rate, the amount of manganese in the environment resulting from use of the Additive is minuscule in comparison to the manganese that occurs naturally in the environment. Indeed, under the 30 percent figure, manganese emissions would be about 1 percent of naturally occurring manganese to the ambient air.[47/] As a result, as discussed below, these manganese emissions would have no discernible effect on concentrations of manganese in the environment.

[46/] (...continued) vehicles) from at least 10,000 to 15,000 square centimeters of surface area. <u>There is no standardized method for conducting such an analysis</u> of materials from an automobile. It would require all of the parts of the automobile that might retain manganese from the Additive (e.g., the combustion chambers, pistons, spark plugs, manifolds, the catalyst, the exhaust pipe(s), and the engine oil and filter) to be removed from the car, their coatings extracted and dissolved in acid, and the remaining solution analyzed for the presence of manganese. To gain access to these surface areas, various components of the automobile would have to be disassembled either directly or by cutting them up. This aspect of the analysis alone would generate substantial uncertainties regarding ultimate results -- e.g., how much of the manganese would be removed from these components simply as a result of the physical removal process? Given the complexity and uncertainties of conducting a material balance, and that emissions (not a material balance) is ultimately the relevant issue to this proceeding, Ethyl has chosen to be conservative by relying on information from the testing of older vehicles without catalytic converters, and assuming that 30 percent of the manganese would be emitted from new vehicles using the Additive.

[47/] <u>See</u> Appendix 2, at p. 2. This assumes that 6.1 percent of total natural global manganese emissions occur in the United States.

2. Use of the Additive will not significantly change environmental levels of manganese.

a. Ambient air

To determine how use of the Additive might affect ambient manganese concentrations, Ethyl analyzed ambient monitoring data from Canada and the United States, where the Additive has been used in gasoline, and the United Kingdom, where it has never been used.[48/]

That the Additive will not appreciably change average ambient manganese concentrations is borne out by Canadian air surveillance data. As noted in Ethyl's original waiver submission, the Additive has been widely used in Canada for over ten years. Nevertheless, ambient manganese concentrations have remained remarkably similar to those in the United States, averaging approximately 0.04 ug/m3 in the largest urban area, Toronto.[49/] In the United Kingdom, where the Additive has never been used, ambient concentrations of manganese have averaged approximately 0.04 ug/m3.[50/]

What the air surveillance data make strikingly clear is that average ambient concentrations of manganese are primarily a

---

[48/] Because average ambient manganese concentrations in urban areas generally exceed those in rural areas, the ensuing discussion focuses on the impact of the Additive on urban ambient manganese concentrations.

[49/] Air Quality Monitoring Reports for 1982-88, Ontario Ministry of the Environment. Ambient concentrations of manganese in urban areas in the United States have ranged from approximately 0.02 to 0.05 ug/m3 from 1970 to the present, and have averaged about 0.04 ug/m3. See Waiver Application, Appendix 8, at p. 4.

[50/] Id. at p. 4, n. 3.

function of large point sources of manganese, such as steelplants, with a significant contribution from natural sources.[51] Whether the Additive is present in fuel has little impact on ambient manganese concentrations. This is confirmed by the one study on ambient manganese referenced by commentators at the public hearing.[52]

Of equal importance, estimated annual emissions of manganese resulting from use of the Additive in <u>leaded</u> gasoline peaked in the United States in the mid-1980s without affecting ambient

---

[51] <u>See, e.g.,</u> Appendix 2, at pp. 2-3; Waiver Application, Appendix 8, Attachment 8-1. Some of the highest ambient manganese levels reflected in data from Canada were obtained in Hamilton, Canada, a city with substantial steel making facilities. <u>Id.</u>

[52] <u>See</u> Transcript, p. 9. This study, "Origins of Manganese in Air Particulates in California," is the only study cited for the proposition that use of the Additive will cause an increase in ambient manganese concentrations. <u>See</u> D.W. Davis, K. Hsiao, R. Ingels, J. Shikiya, "Origins of Manganese in Air Particulates in California," Jour. of Air Pollut. Cont. Assoc. (1988). Even if one accepts this study at face value, however, it shows only that manganese concentrations in California are in the same range as manganese concentrations in the rest of the country -- from 0.015 ug/m3 in the San Francisco Bay area, to 0.03 ug/m3 in Southern California -- even with the use of the Additive in cars not equipped with catalytic converters and at much higher concentrations in fuel (0.1 grams per gallon) than are proposed here. Moreover, while this study claims that the typical vehicular contribution to ambient manganese concentrations could be as high as 20 to 40 percent in Southern California, <u>id.</u> at p. 1156, this represents a manganese concentration of only about <u>0.003 to 0.013 ug/m3</u>. These ambient concentrations are exceedingly small for an area that has perhaps the highest concentration of mobile source traffic in the country.

For these reasons, this study, if anything, supports Ethyl's contention that ambient manganese concentrations associated with use of this Additive will be exceedingly small, even if manganese emissions are much higher than the 0.5 percent level observed in the Ethyl test program.

concentrations of manganese in a material way.[53/] This suggests that the Additive should have little if any impact on ambient concentrations of manganese even in urban areas.[54/]

In order to provide further perspective on this ambient measurement data, an air quality modeling analysis was conducted to predict how use of the Additive in all gasoline would effect ambient manganese concentrations. This analysis predicts an ambient impact in urban areas of less than 0.001 ug/m3 to a maximum of 0.017 ug/m^3.[55/]

These results further confirm that use of the Additive will not significantly affect ambient manganese concentrations, even under "worst-case" assumptions.[56/]

[53/] See Appendix 2, at p. 3. These emissions come from older vehicles, and therefore reflect the higher concentrations of manganese used in those vehicles, and the higher portion of manganese emitted from those vehicles. See supra note 52.

[54/] Indeed, based on the results of the particulate testing, total manganese emissions for 1999 resulting from use of the Additive in all unleaded gasoline would be as much as 20 times less than peak emissions in the mid-1980s. See Appendix 2, at p. 3 (assuming 141 million cars emitting 0.06 grams, or 0.000132 pounds, of manganese annually).

[55/] See Appendix 2, Attachment 2. This modeling analysis therefore produces results consistent with estimates based upon air quality monitoring of manganese. See supra note 52.

[56/] Finally, it should be noted that manganese in the air is deposited fairly quickly as a result of normal atmospheric processes. See Appendix 2, at p. 5. As a result of the short residence time in air, one would expect ambient manganese levels to remain relatively constant over time, at levels in the 0.02 to 0.05 ug/m3 range. Id.

b. Soil

Typical manganese levels in soil average about 1000 ppm, or about one kilogram per cubic meter of soil.[57] Use of the Additive would not appreciably affect these manganese soil levels because, among other things, the amount of ongoing manganese deposition would remain essentially unchanged, even if all unleaded gasoline in the United States contained the Additive.

For example, assuming that by 1999 the Additive would be used in all gasoline, Ethyl estimates that use of the Additive would increase manganese deposition by approximately 0.05 to 3 g/ha/yr (depending on whether one assumes 0.5 percent or 30 percent of the manganese in the Additive is emitted). This would reflect an increase in the current deposition rate of manganese of only about 0.005 to 0.3 percent.[58]

Another way to look at the potential effect of manganese emissions on soil concentrations is to relate predicted manganese emissions resulting from use of the Additive to the impact of tetraethyl lead emissions on lead concentrations in soil. Based on the amount of manganese emitted from the tailpipe reflected in the FTP particulate testing completed by Ethyl,[59] average soil concentrations of manganese only one meter from an expressway carrying 100,000+ cars/day would increase from about 1000 ppm, on

---

57/ HAD, supra, note 4, at 3-27.

58/ Appendix 2, at p. 10.

59/ See supra pp. 19-20.

average, to only 1000.1 ppm after 50 years of use.[60] Even if one assumed that the percentage of manganese emitted would be the same as that for lead in gasoline, manganese soil concentrations one meter from the expressway would increase, after 50 years of use, from 1000 ppm, on average, to approximately 1012 ppm.[61] As the distance from the expressway increases, the Additive's contribution to manganese in soil concentrations decreases, becoming indistinguishable from background even under worst case assumptions beyond about 15 meters.[62]

Indeed, even after 50 years of use of the Additive, maximum manganese concentrations from the Additive in the soil five meters from a busy expressway would be less than the concentration of manganese in a single cup of tea (4.6 ppm versus 6.9 ppm).[63] Moreover, watering one's lawn once a year for 50 years would contribute about the same amount of manganese to the soil as would maximum manganese deposition from cars using the Additive in soil only five meters from a busy expressway.[64]

The small increase in deposited manganese associated with use of the Additive would, therefore, have no measurable effect on soil manganese levels. As one Canadian study reports:

---

[60] Appendix 2, Attachment 2, Table 1.

[61] Id. As noted, the assumption that manganese would be emitted in the same amount as lead in gasoline is very conservative. See supra note 46.

[62] Appendix 2, Attachment 2, Table 1.

[63] See infra note 74.

[64] Appendix 2, at p. 6.

> Manganese oxides that reach the soil are not likely to remain concentrated in the upper few centimeters for any length of time. The pH of the generally moist conditions prevailing in soils will cause mobilization of the manganese, which will move to lower levels and ultimately reach the groundwater or surface waters (Costescu and Hutchinson, 1972). Thus the manganese of gasoline origin actually reaching human populations will indeed be almost exclusively directly inhaled or ingested, in incremental quantities insignificant compared with normal exposure through food or respiration....[65]

This conclusion is also confirmed by a modeling analysis performed by SAI, Inc. Based on conservative assumptions regarding urban ambient manganese concentrations and the contribution of mobile sources to those concentrations, SAI concludes that "even in 70 years, [and even] ignoring losses to the subsoil and ground water, the increment to the crustal burden would not be distinguishable" from natural variability in manganese concentrations.[66]

As the Royal Society of Canada has concluded, therefore, the "potential accumulation [of manganese] in dusts and soils over extended periods of time" is not a legitimate concern.[67]

---

[65] *See* The Royal Society of Canada, "Lead in Gasoline: Alternatives to Lead in Gasoline," (February 1986), at pp. 7-8. This study is attached hereto as Appendix 5.

[66] *See* Appendix 2, Attachment 1 (emphasis added).

[67] *See* Appendix 5, at p. 7. Nor does the disposal of automobiles operated on fuel containing the Additive present a concern. Assuming that all of the manganese used in the Additive remains in the internal systems of the vehicle, this would only amount to a little more than 100 grams of manganese after 100,000 miles of vehicle operation. Eventually, the automobile would be recycled at a steel plant and the manganese that remained in the (continued...)

4. Given the small contribution of manganese to the air and soil, use of the Additive will not discernibly change the public's exposure to manganese.

As discussed above, even if the Additive is used in all unleaded gasoline, manganese concentrations in the air and soil will change little if any. As a result, public exposure to manganese will, from a practical standpoint, be little different than it is today.

Health authorities recommend, for example, a normal daily intake of manganese ranging between 2,000-5,000 ug,[68/] although higher levels are recommended for pregnant women, children, and the elderly.[69/] On a daily basis, an individual typically takes in 2,000-9,000 ug of manganese through ingestion of food and water, and about 0.8 ug from the air.[70/] About 120 ug of this typical daily intake would be absorbed by the body, given the

---

67/ (...continued)
vehicle would be alloyed into new steel stocks. Of note, automotive materials contain a large amount of manganese in their own right, averaging 7 to 8 pounds of manganese in the form of steel alloy.

Moreover, analysis of the used oil from the Ethyl test fleet cars indicate that that oil contains approximately 150 parts per million manganese. This represents only about 6 grams total manganese in the used oil over 100,000 miles of vehicle operation, assuming oil changes every 7500 miles. Because most used oil is re-refined or otherwise disposed of in a proper environmental manner, small increases in manganese concentrations in oil will not create public health concerns.

68/ See Estimated Range of Safe and Adequate Intake, National Research Council (1980); HAD, supra note 4, at 3-87.

69/ Appendix 7, at Attachment 2.

70/ See HAD, supra note 4, at 3-81 to 3-90.

body's well-documented mechanism for regulating manganese uptake.[71]

Exposure to manganese from use of the Additive will not, as a practical matter, change these existing exposure levels. For example, based on conservative assumptions regarding ambient concentrations of manganese and mobile source contributions to these concentrations, SAI concludes that, even after 70 years of accumulation, manganese intake due to use of the Additive will be, at most, less than 2 ug each day. This is less than 0.1 percent of the amount of manganese typically taken in by the body on a daily basis.[72] It should be noted that this analysis accounted for both inhalation and ingestion exposure pathways.

Moreover, normal variations in manganese intake from diet can range up to 7000 ug per day -- thousands of times greater than the maximum potential contribution of the Additive to manganese intake, based on the SAI exposure analysis.[73] Maximum manganese intake from use of the Additive would be totally overwhelmed by --

- A multivitamin tablet (1,000-10,000 ug)
- An afternoon a cup of tea (1,200 ug),[74]

---

[71] See id. at 4-13.

[72] See Appendix 2, Attachment 1.

[73] See id., Attachment 1.

[74] Shrestha, K.P. and G.N. Schrauzer, Trace Elements in Hair A Study of Resident in Darjeeling (India) and San Diego, California (continued...)

- A decision to eat a slice of whole grain bread instead of white bread (a difference of 170 ug),[75] or
- Eating a banana instead of an apple (a difference of 210 ug).[76]

As can be seen, public exposure to manganese that results from use of the Additive will be totally insignificant.

5. Concentrations of manganese in the environment associated with use of the Additive will not <u>adversely affect the public health or welfare.</u>

Because manganese emissions from use of the Additive will not appreciably change the public's exposure to manganese, use of the Additive will have no adverse effect on public health or welfare.[77] The potential public health effects of low levels of manganese in the environment have been examined repeatedly by the

---

[74] (...continued) (U.S.A.), The Science of the Total Environment, Vol. 79, 171-177 (1989). This amount is the same as 6.9 ppm. <u>See</u> Waiver Application, Appendix 8, at p. 5.

[75] Gutherie, B.E., "Chromium, Manganese, Copper, Zinc and Cadmium Content of New Zealand Foods, New Zealand Med. J., December 24, 1975, 418-424.

[76] <u>Id.</u>

[77] Indeed, of more concern than over-exposure to manganese from the environment is under-exposure. Since manganese is especially important to the health of the young, the elderly, and pregnant woman, manganese supplements may be recommended as part of the diet. In this sense, manganese is very different from pollutants regulated by EPA as "carcinogens" (such as benzene), where any increment of exposure, no matter how small, is assumed to present a health risk. Given the important nutritional role of manganese, low level exposures are needed to sustain life.

Indeed, there are other elements which are essential to life at low levels but are toxic at extremely high levels, such as Vitamin B-6. <u>See</u> Washington Post, Health Section (July 10, 1990)("large doses of vitamin B-6 can temporarily damage your nerves, causing numbness and difficulty using some of your muscles").

United States and other governments. As discussed below, these studies confirm that low levels of manganese in the environment -- including those from point sources at levels several orders of magnitude higher than any levels potentially associated with use of the Additive -- present no public health concern from <u>any</u> standpoint, including potential neurotoxicological effects.

a. Governmental reviews of <u>manganese health effects</u>

In 1985, EPA issued a final "Health Assessment Document for Manganese" ("HAD").[78/] The final HAD reflects a comprehensive review by EPA's staff of the available health studies on manganese. In producing the HAD, the staff reviewed over 500 references addressing the occurrence of manganese in the environment, its metabolism, pharmaco-kinetics, and relationships to health. The EPA staff released several drafts of their review of these studies for public review and comment, and sought the advice of the Agency's Science Advisory Board, a group of independent scientists, before issuing the HAD in final form.

Based on this review, EPA concluded that manganese, at ambient levels as high as 250 ug/m3 for fifteen minutes and 125 ug/m3 for 8 hours, would not "cause, or contribute to, air pollution which may reasonably be anticipated to result in an increase in mortality or an increase in serious . . . illness."[79/] Such levels are <u>4 to 5 orders of magnitude higher than the levels</u>

78/ <u>See</u> 50 Fed. Reg. 32627 (1985).

79/ <u>Id.</u> at 32628, col. 2 (EPA decides "not to regulate manganese as a hazardous air pollutant").

of manganese predicted to occur with use of the Additive.[80/] A complete copy of the HAD is attached to these supplemental comments as an attachment to Appendix 3.

Similarly, in September 1988, the Health Effects Institute ("HEI"), an independent scientific body jointly funded by EPA and the automobile manufacturers to evaluate the public health impacts of fuels and fuel additives, issued a report entitled "Potential Health Effects of Manganese in Emissions from Trap-Equipped Diesel Vehicles." The purpose of the study, which is an attachment to Appendix 3, was to consider "the potential health effects from increased public exposure to manganese emissions" resulting from use of manganese fuel additives in diesel fuel. The HEI report examined at some length the health literature on manganese, including epidemiology and human and animal toxicological studies.

Based on its independent evaluation of the public health effects of manganese, HEI concluded that no adverse neurological or respiratory health effects would result from an increase in manganese emissions, even at projected manganese levels two orders of magnitude higher than those that would be expected to result from use of the Additive.[81/] Like the HAD, this conclusion

---

80/ See supra notes 48-56 and accompanying text.

81/ The HEI analysis was based on a worst-case concentration of manganese in ambient air of 0.5 ug/m3. HEI concluded that "it appears very unlikely that exposure to [this level of airborne manganese] would produce adverse neurological effects." HEI Report at 35. HEI further concluded that "the levels of airborne manganese derived from fuel additives in a trap-equipped diesel-
(continued...)

reflects a comprehensive and independent review of the available literature on manganese and public health.

Nor is the United States the only country to have investigated the public health effects of manganese. Several Canadian studies which have directly focused on the use of the Additive and how it might affect public health have concluded that use of the Additive does not present public health concerns.

The first of these studies, completed in 1978 by the Department of National Health and Welfare, concludes that even under worst conditions, (i.e., manganese concentrations less than 5 ug/m^3 for a 24-hour averaging time) a

> "[r]eview of available limited information on industrial and community exposure to manganese and results of studies in animals of chronic inhalation of manganese exhaust products leads to the conclusion that there is no evidence at present to indicate that expected ambient manganese concentrations would constitute a hazard to human health."[82/]

81/ (...continued) powered automobile are not likely to produce adverse respiratory effects in the general public." HEI Report at 36. Even if 30 percent of the manganese in the Additive were emitted into the air, the resulting maximum concentration would be over an order of magnitude below the level considered safe by HEI.

Because the levels of manganese resulting from use of the Additive are significantly below those evaluated by HEI, HEI's recommendations for further evaluation of the flawed study by Nogawa, et al. (1973), in which children exposed to an estimated 3 to 11 ug/m3 of manganese reportedly experienced respiratory effects, is inapplicable here. Nevertheless, the Nogawa study is considered further in Appendix 3, at C-8 and Attachments C-12 and C-13.

82/ A copy of the study is attached to these supplemental comments as Appendix 4. The quote can be found at p. iv (emphasis added).

A subsequent report completed by the Royal Society of Canada in 1986 reaches the same conclusion. The report, attached hereto as Appendix 5, states that

> MMT has already been used, however, for 8 years in unleaded gasoline, which currently comprises about half the gasoline consumed in Canada. The additional exposure to manganese is well within the normal range represented by dietary variations, and is likely to remain so. . . <u>Cooper's view (1984) that the general public has a wide margin of health safety with respect to the worst case use of MMT in gasoline appears to be sound</u>.[83/]

Finally, an official of Australia's Department of Health completed a comprehensive evaluation of the literature on the public health implications of manganese in 1987. In this report, this Australian official concludes that

> [o]n the basis of present information, <u>there is no toxicological evidence to suggest that the increased level of airborne Mn resulting from the combustion of MMT as a petrol additive is likely to constitute a health risk to the general population</u>.[84/]

These studies demonstrate in a very concrete way that the potential health implications associated with use of the Additive have already been exhaustively reviewed by a variety of independent scientists. These comprehensive and independent reviews have uniformly concluded that low level concentrations of

---

83/ Appendix 5, at p. 11 (emphasis added).

84/ Appendix 3, Attachment C-16, at 254 (emphasis added). Indeed, the National Health and Medical Research Council of Australia concluded "that there were no toxicological concerns over the use of MMT in petrol." <u>See</u> Letter to Keith Wilson from Dr. G.J. Murphy dated October 15, 1987, attached as Appendix 6.

manganese in the environment present <u>no</u> public health concern.[85]

To insure that nothing has appeared in the health literature on manganese since issuance of any of these studies which might affect the conclusions of these independent reports, Ethyl asked Dr. H. Daniel Roth of Roth Associates, Inc., to review the health literature made available subsequent to the publication of the HEI report. Dr. Roth and his associates have substantial experience on health issues generally and manganese specifically. Dr. Roth concludes that nothing in the more recent health

---

[85] For this reason, the suggestion by the National Institute for Environmental Health Studies ("NIEHS") in its comments dated June 7, 1990 (docket entry IV-H-1) and others that additional research should be done to determine the health effects of manganese <u>before</u> a decision is made on Ethyl's waiver application is misguided. NIEHS, for example, makes no effort in its comments to explain why the Agency should disregard the numerous analyses already completed by EPA and others that conclude that low levels of manganese exposure present no public health concern. It is also interesting to note that most of Dr. John Donaldson's recommendations for additional research to the Canadian Government involve manganese at levels found in <u>industrial</u> settings, not those low level concentrations to which the general population is exposed. <u>See</u> P.M. Stokes, P.G.C. Campbell, W.H. Schroeder, C. Trick, R. L. France, K.J. Puckett, B. Lazerte, M. Speyer, J.E. Hanna, J. Donaldson, "Manganese in the Canadian Environment (1988), at 109-111.

Indeed, if NIEHS is concerned with low level manganese exposures, it is curious that NIEHS did not make these concerns known to the Agency when it drafted the HAD. While more research can always be pursued to improve man's understanding of the environment and its affects on human health, NIEHS's assertion that not enough is known to make a reasoned judgment about the Additive's potential effects on public health is directly contradicted by the numerous, independent scientific judgments that have already been made.

For a detailed response to the NIEHS comments, <u>see</u> Appendix 3, at D-1 to D-4 and Attachment D-1.

literature on manganese would provide a basis for changing the conclusions of these earlier reports. He states:

> [W]e have found that the use of MMT is unlikely to affect public health adversely. The anticipated increase of manganese in the environment from use of MMT is sufficiently small in comparison to the natural levels of this element and human intake of it that the body's ability to maintain consistent manganese levels should be unaffected. In fact, manganese in small quantities is an essential nutrient. Thus, no adverse effect on health would be anticipated. Data concerning the impact of exposure to the quantity of airborne manganese expected to result from approval of MMT are limited but are consistent with this conclusion.[86/]

The independent determinations by United States, Canada, and Australia that low level manganese concentrations do not create a public health concern remain valid and relevant to this proceeding.

b. <u>None of the comments raised at the public hearing or in comments to date cast any doubt on the continuing validity of the unanimous findings of the HAD and the other independent governmental reviews that low level manganese concentrations present no public health concern.</u>

In spite of the substantial attention that manganese has received from numerous independent scientific bodies, the Agency has received several comments which suggest that manganese emitted from the tailpipe will adversely affect public health. None of these specific allegations, however, withstand critical analysis.

86/ Appendix 3, at F-1.

Initially, manganese is not lead. Any such suggestion to the contrary is simply wrong, and should raise serious questions concerning the credibility of the commentator. As one investigator has indicated:

> A number of toxicological concerns regarding increased airborne levels of Mn3O4 from use of MMT appear to have arisen by comparison with . . . lead. A major reason why this is an inappropriate analogy is that Mn is already present in the diet and is absorbed via the GI tract at a high level in comparison to the expected level of pulmonary absorption of Mn oxides. While Mn may be present in a variety of salts and oxides in food and air, and the relative absorption rates of these forms of Mn may vary, their toxicological effects are considered to be identical following absorption.[87/]

Indeed, manganese is essential to human health at all stages of human development. A deficiency of manganese, for example, has been associated with osteoporosis in the elderly,[88/] while

---

87/ Appendix 3, Attachment C-16, at 249-50 (emphasis added). Dr. Carl Schulz, a toxicological consultant to Roth Associates, further explains that lead and manganese differ chemically, environmentally, and biologically. Chemically, for example, manganese is a light metal, more like iron, than it is like the heavy metal lead. Environmentally, naturally-occurring levels of manganese are far higher in food, air, and water than are levels of lead. Biologically, "[h]omeostatic mechanisms appear to regulate the uptake and excretion of manganese in higher animals such that individuals having widely different intakes of this element have similar body burdens." See Appendix 3, Attachment D-2. Finally, as noted by several studies, the behavior of manganese in the soil differs from that of lead. See supra pp. 27-28.

88/ Straus, L. and R. Saltman, Role of Manganese in Bone Metabolism, Nutri. Biochem. of Manganese, ACS Symposium Series No. 354 (Amer. Chem. Society 1987), Constance Keys, ed., 46-55.

physicians regularly prescribe vitamin supplements containing manganese for pregnant woman.[89/]

Moreover, Dr. John Donaldson and others allege a whole host of potential adverse health effects attributable to manganese. Their allegations, however, share several common errors. First, they generally fail to distinguish between exposure to high versus low concentrations of manganese. Second, they make no effort to relate "potential" adverse effects of manganese to increased manganese levels in the environment. Third, they rely on speculative "associations," and acknowledge that research on these alleged associations has "never really been addressed."[90/] Each of these errors is illustrated below. The specific issues raised by these commentators are addressed at length in Appendix 3.[91/]

- Dr. Donaldson and the Environmental Defense Fund (EDF) allege that chronic exposure to manganese, especially while young, contributes to neurological diseases of aging such as Parkinson's disease.[92/] There is, however, no evidence that low levels of manganese damage neurons. Moreover, evidence suggests that neurological effects from elevated levels of manganese differ in mechanism and neuropathy from Parkinson's disease.[93/]

89/ See Appendix 7, Attachment 2.

90/ Transcript, at p. 63.

91/ See Appendix 3, at D-1 to D-7, and Attachments D-1 to D-4.

92/ Congressmen Waxman, Madigan, Sikorski and Richardson raised similar concerns in a letter to the Administrator. See Docket Entry IV-D-21.

93/ Id. at D-5 to D-7 and Attachments D-3 and D-4.

- Dr. Donaldson and Everett Hodges allege that elevated levels of manganese in human hair are associated with violent, criminal behavior. The sole support for this allegation is an unpublished, seriously flawed paper. Moreover, no relationship between environmental exposure to manganese and the purportedly elevated manganese levels in the hair of criminals is shown. Nor is there any evidence that such concentrations are causally related to criminal behavior.[94/]

- Dr. Donaldson, Dr. Herbert Needleman, NIEHS and EDF describe manganese as a neurotoxin. All evidence of neurotoxic effects from manganese results from exposures to manganese that are several orders of magnitude above that that would result from use of the Additive. Long-term exposure to manganese in food and water, and to ambient air around manganese point sources at levels well above those that would result from the Additive, produces no neurotoxic effect.[95/]

- EDF alleges that manganese is a lung toxin. EPA has developed a No Observed Effects Level and a Lowest Observed Adverse Effects Level for respiratory effects in sensitive humans, both of which are over 4 orders of magnitude (i.e., a factor of ten thousand) higher than the maximum anticipated contribution of the Additive to manganese in the ambient air.[96/]

- EDF and NIEHS allege manganese causes fetal and reproductive effects. The only evidence of such effects comes from exposures many times higher than that that would result from use of the Additive.[97/]

- NIEHS alleges that manganese can be absorbed through the nose with a resulting "straight shot to the brain." Inhaled manganese oxides are exhaled by normal clearance mechanisms, and where absorbed into general circulation, must pass through the heart, lungs, the kidneys and the liver before reaching the brain. Inhaled manganese is therefore subject to the normal homeostatic mechanisms that regulate body burdens of

---

94/ Id. at C-2 to C-4, D-4 to D-5, Attachments C-2 and C-3.

95/ Id. at D-2, D-4 to D-6.

96/ Id. at B-4, D-6 to D-7.

97/ Id. at B-4, B-5, and D-7.

manganese. "There is no shortcut from the nose to the brain."[98/]

- EDF alleges that accumulations of manganese over time will be of more concern than emissions of toxic substances such as benzene.[99/] To the contrary, even under worst case assumptions, manganese will not accumulate in discernible quantities even over 50-70 years.[100/] By contrast, emissions of benzene, formaldehyde, and other noxious substances will be reduced with each gallon of gasoline containing the Additive, producing continuing health benefits.[101/]

Finally, in light of the public health concerns expressed at the public hearing, Ethyl has asked several additional well-known physicians and epidemiologists to review the available evidence and to provide independent assessments of the public health concerns associated with use of the Additive. One of these is Dr. Henry Wisniewski, M.D., Ph.D. Dr. Wisniewski is a neuropathologist, an authority on myelin and neurofibrillary pathology and aging and Alzheimer's disease, and the author of over 400 research papers. He is also the current Director of the Institute for Basic Research, the research arm of the New York State Office of Mental Retardation and Developmental Disabilities.

Based on his independent review of the literature on manganese and the public hearing testimony, Dr. Wisniewski concludes that "Ethyl provided enough evidence to show that

---

98/ Id. at D-2 and Attachment D-1.

99/ See Transcript at p. 17.

100/ See Appendix 2.

101/ See Appendix 3, at E-1 to E-5.

adding Mn to their products will not negatively affect human health and the environment."[102/] While noting that manganese has been associated with several neurotoxic effects, Dr. Wisniewski cautioned that "there is no evidence to suggest that similar effects take place at lower Mn exposure levels."[103/] On balance, Dr. Wisniewski wrote, the evidence "is clearly in favor of approving Ethyl's application."[104/]

Similarly, Ethyl asked Dr. Robert Lauwerys, a professor of Industrial Toxicology and Occupational Medicine, and Director of the Unit of Industrial Toxicology and Occupational Health at the University of Louvain in Brussels, Belgium for his independent opinion on the public health implications associated with use of the Additive. Dr. Lauwerys has done extensive work on the health effects of manganese, having published over 400 papers and books, a large number of which are on the subjects of manganese and other metals. Based on his review of the health literature, Dr. Lauwerys concluded that the World Health Organization's ("WHO") recommended guideline of 1 ug/m3 average manganese exposure "should incorporate a sufficient margin of protection <u>for the most sensitive population group</u>."[105/] As has been noted, use of

---

[102/] Appendix 7, Attachment 1.

[103/] <u>Id.</u>

[104/] <u>Id.</u>

[105/] <u>See id.</u>, Attachment 2 (emphasis added). A copy of the WHO's guidelines on manganese referred to by Dr. Lauwerys statement is provided in Appendix 7, as Attachment 3. In these guidelines, the WHO concludes that the "available evidence (continued...)

the Additive will result in ambient manganese levels which are one to two orders of magnitude below the WHO's 1 ug/m3 guideline.[106/]

Finally, Ethyl also asked Dr. C.W. Cooper for a similar independent review and evaluation of the health literature on manganese as it bears on this waiver application. Dr. Cooper was an official with the U.S. Public Health Service for almost 25 years, ultimately retiring as Medical Director of the service, and has published over 50 papers on occupational safety and other health issues. In 1984, Dr. Cooper conducted a comprehensive review of the then-existing literature on the public health implications of manganese in the environment. In that review, Dr. Cooper concluded that the "minute increments of Mn that would result from the use of MMT as a gasoline additive should not have any impact on the public's health."[107/] Dr. Cooper has recently reviewed the available literature on manganese and public health once again. Following this review, Dr. Cooper indicated that "[a]s of July 1990, I am not aware of any new evidence to alter

---

105/ (...continued)
indicates that the current manganese levels generally found in industrialized countries are not in the concentration range associated with potentially harmful effects." Id. In this regard, the WHO indicated that annual average ambient manganese concentrations ranged from as low as 0.01 ug/m3 in "nonpolluted areas" to as high as 0.3 ug/m3 in areas near foundries. Id.

106/ See supra pp. 23-25.

107/ Appendix 7, Attachment 4.

the[] conclusions [of the 1984 review]; if anything they have been strengthened."[108/]

These additional, independent reviews of the public health implications associated with use of the Additive confirm the conclusions arrived at separately by the governments of the United States, Canada, and Australia, and others. Low level ambient concentrations of manganese on the order of those associated with use of the Additive present no public health concern.

C. Ambient Exposure to the HiTEC 3000 Additive Does Not Present a Public Health Risk.

As explained in Ethyl's initial waiver submission, the Additive itself, as contrasted with the emission products from combustion of the Additive, does not present a public health concern.[109/] Because of the very low concentration at which the Additive would be used in gasoline (0.03125 grams manganese per gallon), its low vapor pressure, its decomposition in sunlight in seconds, and its almost complete combustion in the engine (at least 99.9%), the public will not be exposed to measurable amounts of the Additive.[110/] This was the conclusion reached by

---

108/ Id.

109/ See Waiver Application, Appendix 8, at 13-15. The representative from EDF testified at the public hearing that "my concern is not with MMT." Transcript, at p. 18.

110/ Manganese Exhaust Products, supra note 45; D.R. Lynam, G.D. Pfeifer, B.F. Fort, A.A. Gelbcke, "Environmental Assessment of MMT Fuel Additive," The Science of the Total Environment, 93 (1990) 107-114; M. Coe, R. Cruz, J.C. Van Loon, "Determination of Methylcyclopentadienyl Manganese Tricarbonyl by Gas

(continued...)

Canada's Department of Health and Welfare in 1978 and by the Royal Society of Canada in 1986.[111/] It is also substantiated by air surveillance data which shows that, notwithstanding use of the Additive in Canada during 1978, it was not detected in ambient air at several locations at street level in Toronto, Canada at a detection limit of 0.00005 ug/m3.[112/]

In addition, the OSHA permissible exposure limit and the American Conference of Governmental Industrial Hygienists' threshold limit value for the Additive is 200 ug/m3. Workplace exposures, however, are typically less than 100 ug/m3 and refinery concentrations less than 10 ug/m3. While in its undiluted form, the Additive is toxic by inhalation and moderately toxic dermally, there is no risk of intoxication from normal handling or use of gasoline once blended into gasoline at recommended concentrations.[113/]

110/ (...continued)
Chromatography Atomic Absorption Spectrometry at ng m-3 Levels in Air Samples," Analytica Chimica Acta, Vol. 120 (1980) 191-176.

111/ See Appendix 4, at p. 17; Appendix 5, at p. 7.

112/ Coe, et al., attached hereto as Appendix 8. In this regard, one commentator presented a calculation that purports to show the amount of the Additive that would be emitted to the environment if it was present in all gasoline. See Letter to Air Docket from Herbert Needleman dated June 14, 1990 (docket entry IV-D-06). Aside from the fact that this commentator has, from an arithmetical standpoint, incorrectly overstated total emissions of the Additive by one order of magnitude, he has also totally ignored the fact that, as noted above, the Additive is almost completely combusted in the engine, and that whatever traces remain decompose in seconds in the presence of sunlight.

113/ Waiver Application, Appendix 8, at p. 14.

D. Use of the Additive Will Promote the Overall Objectives of the Act.

In filing its waiver application, Ethyl devoted substantial resources to demonstrating that the Additive will not cause or contribute to the failure of emission control devices or systems to meet applicable emission standards. Recognizing that the Agency's decision should also serve the broader purposes of the Act, however, Ethyl showed that approval of its application would promote the "public health and welfare," and the "productive capacity" of the nation.[114/]

In the preceding sections and in the waiver application, Ethyl has shown that use of the Additive will have a beneficial effect on the public health and welfare.[115/] In addition, use of the Additive will benefit the productive capacity of the nation. Use of the Additive could reduce crude oil imports by about 30 million barrels of oil annually, or more oil than the Nation places in the Strategic Petroleum Reserve each year.[116/] At $18 per barrel, this amounts to a reduction in the nation's balance of payments of nearly $540 million per year. Alternatively, use of the Additive would cut capital investment in octane producing units by nearly $730 million.[117/] Finally, as one refiner has

---

114/ CAA § 101(b); <u>see</u> <u>infra</u> pp. 7-8.

115/ <u>See supra</u> pp. 13-19. <u>See also</u> Appendix 3, at E-1 to E-5.

116/ Waiver Application, Appendix 6, at pp. 5-7.

117/ <u>Id.</u> at p. 7.

noted, use of the Additive would "ultimately result[] in less costly gasoline for the consumer."[118/]

As the Agency has recognized, a "balancing of the social and economic considerations with the environmental implications [of a decision is necessary] . . . to fulfill the mandate of the Clean Air Act to 'protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population.'"[119/] In this case, Ethyl has shown that use of the Additive will further all of the objectives of the Clean Air Act. Accordingly, this application should be approved.

IV. USE OF THE ADDITIVE WILL ENHANCE CATALYTIC EFFICIENCY WITHOUT CAUSING PLUGGING OR OTHER ADVERSE EFFECTS ON EMISSION CONTROL SYSTEMS.

This section of the supplemental comments is intended to respond briefly to other technical issues raised at the public hearing on Ethyl's waiver application, including EPA's requests for additional information. Should the automobile manufacturers or others comment for the first time in July, Ethyl will respond expeditiously to those comments.

118/ See Letter from Ray Freels, President, Kerr-McGee Refining Corporation, to Mary Smith dated June 29, 1990 (docket entry IV-D-22).

119/ 39 Fed. Reg. 31,000 col. 1 (Aug. 17, 1974) (emphasis added); see also Chrysler Corp. v. EPA, 631 F.2d 865, 888 (D.C. Cir. 1980); General Motors Corp. v. Ruckelshaus, 742 F.2d 1561, 1572 n.15 (D.C. Cir. 1984); Ethyl Waiver Application 60-62.

A. The Change in Emissions Associated with Use of the Additive is Attributable to the Catalytic Properties of Mn_3O_4.

At the public hearing on Ethyl's waiver, the EPA panel expressed interest in an explanation as to why the Additive reduced NOx and CO emissions, and increased HC emissions slightly in the test program. Since the public hearing, Ethyl contacted Dr. Roy Harrison, the Director of the Institute of Aerosol Science at the University of Essex in England. In written comments prepared on Ethyl's behalf, Dr. Harrison attributes the reduction in NOx and CO emissions to the catalytic properties of Mn_3O_4. As explained by Dr. Harrison:

> Operation of vehicles on fuel containing MMT additive causes deposition of a surface coating of the manganese oxide, Mn_3O_4 on the internal surface of the exhaust system. This coating has catalytic properties which cause decomposition of nitric oxide to N_2 and O_2, and may also catalyze loss of carbon monoxide by reaction with O_2, or with NO. This catalytic effect leads to an improvement in exhaust gas relative to vehicles running on clear fuel which increases with the age of the vehicle as the catalytic coverage of Mn_3O_4 grows.[120/]

With respect to HC emissions, the slight increase in emissions observed in the test program appears to be an engine-out increase. All evidence indicates no reduction in catalyst efficiency for HC emissions compared to clear fuel cars.[121/] Most importantly, there is no evidence that the slight HC increase causes or contributes to the failure of the emission control

---

120/ Appendix 9, at 5.

121/ Waiver Application, Appendix 3.

systems to meet either the current or future HC emission standards.[122/]

B. Use of the Additive Will not Cause Plugging of Catalytic Converters.

As a part of Ethyl's extensive test program, Ethyl conducted several tests designed to determine whether the Additive had an adverse effect on catalytic converter efficiencies. These tests, which are described in detail in Appendix 3 to the waiver application, show that after 75,000 miles of vehicle operation, use of the Additive:

1. Improved catalytic converter efficiency for NOx emissions, with no detrimental effect on converter efficiency for HC and CO emissions;

2. Had no adverse effect on catalytic converter back pressure measurements;

3. Had no adverse effect on catalytic converter plugging tendencies under high speed conditions;

4. Had no adverse effect on catalytic converter back pressure measurements or converter efficiencies in a set of vehicles operated more than 100,000 miles; and

5. Had no adverse effect on the reliability of oxygen sensors.

The results of these tests are fully consistent with several Canadian studies which have investigated whether use of the Additive, at concentrations up to twice those requested in Ethyl's waiver application, causes plugging in catalytic

---

[122/] Id. at Appendix 2A and 2B.

converters. In 1986, for example, the Royal Society of Canada concluded that:

> in eight years of use of MMT in unleaded gasoline in Canada there does not appear to have been a higher incidence of catalytic converter failure than in the United States. MMT does not appear to cause failure of the oxygen sensor or deactivate the catalyst. The converters that were prone to plugging in the 1970's were of the monolithic type, consisting of a ceramic base impregnated with the precious metal catalyst. The pore size of these catalysts was much smaller than the modern pelletized catalysts which prevent the development of engine back pressure.[123/]

Similarly, in 1986, the Canadian Government Specifications Board ("CGSB") completed a study entitled, "An Assessment of the Effect of MMT on Light-Duty Vehicle Exhaust Emissions in the Canadian Environment."[124/] In this report, the CGSB concluded that the "use of MMT at current CGSB levels does not significantly compromise emission-control system operation or component durability."[125/] Of particular note, the CGSB had solicited information from the both the Motor Vehicle Manufacturers Association and the Automobile Importers of Canada. Both organizations reported "that manufacturers' Canadian warranty claims on emission components are comparable to the U.S."[126/]

[123/] Appendix 5, at 6.

[124/] The CGSB study has been attached hereto as Appendix 10.

[125/] _Id._ at 10.

[126/] _Id._ at 6.

A more recent study completed by Petro-Canada, Inc. reaches the same conclusion.[127] In a letter to the docket for this proceeding, Petro-Canada, Inc. reports that:

> In common with the other major gasoline producers, we have sold MMT containing gasoline in Canada since 1976 at up to twice the concentration applied for in the [Ethyl] waiver. Thus Canadian automobiles have collectively been exposed to MMT for many millions of miles and many individual vehicles to well over 100,000 miles of operation. <u>We have not had a single complaint referencing catalyst plugging</u>.
>
> In addition, our research department has examined a number of catalysts from our high mileage in-house test fleet <u>without finding evidence of catalyst plugging</u>.
>
> We have discussed the issue several times with the auto manufacturers and are aware of their concerns; however, <u>they have not submitted any evidence that MMT is associated with catalyst plugging</u>.[128]

The only study of which Ethyl is aware that suggests the Additive might cause catalyst plugging under normal driving conditions was sponsored by Ford Motor Company.[129] This study, however, is flawed in several critical respects. First, the conclusions presented in the paper ignore the effect of potential

---

[127] Petro-Canada, Inc. is an oil company, wholly-owned by the Canadian government.

[128] Letter dated June 26, 1990 to Mary T. Smith from R.E. Dart, Petro-Canada, Inc., at p. 1.

[129] <u>See</u> R.G. Hurley, W.L. Watkins, R.C. Griffis, "Characterization of Automotive Catalysts Exposed to the Fuel Additive MMT," SAE Paper No. 890582 (1989).

misfueling and lead content on catalysts.[130] High lead concentrations are known to deactivate noble metal catalysts, and may have had that effect on the catalysts of the Ford test vehicles. Second, Ford assumed that all of the test vehicles were operated under normal conditions, with proper routine maintenance. Neither of these conclusions is substantiated in the paper.[131]

Finally, and most notably, the catalyst conversion efficiencies reported in the Ford paper were based on laboratory methods for which no correlation with actual field emissions testing is shown. By contrast, Ethyl's extensive test program demonstrates in actual practice after 75,000 miles of vehicle operation (and beyond) that use of the Additive will not adversely affect operation of the catalyst and, in fact, improves conversion efficiency for NOx emissions.

The overwhelming evidence therefore supports the conclusion that use of the Additive will not cause plugging in catalytic converters.

C. Use of the Additive Will Complement the Use of Oxygenates, Not Replace Them.

As noted by Ethyl in its application and at the public hearing, use of the Additive is fully compatible with the use of

---

[130] See Ethyl Corporation, "Characterization of Automotive Catalyst Exposed to Fuel Additive MMT: Comments on SAE Paper 890582," (March 1, 1989), attached hereto as Appendix 11.

[131] Id.

oxygenates in unleaded gasoline.[132] For example, the Additive complements the octane improving characteristics of oxygenates such as MTBE and ethanol, and will not adversely affect automotive materials used in fuel systems when mixed with oxygenates.[133]

Moreover, future unleaded fuel stocks would likely contain both the Additive (if approved) and oxygenates. A limitation on the aromatic content of gasoline, for example, will create a shortage of octane-producing capabilities in U.S. refineries.[134] Under these circumstances, refineries will likely use the Additive to the fullest extent, but would still have to blend oxygenates into the fuel in substantial amounts.[135] In addition, several areas of the country have imposed minimum oxygen requirements in gasoline, especially during the winter months.[136] In these areas, the Additive will not displace oxygenates since the Additive does not add oxygen to gasoline.

132/ See Ethyl's "Testimony in Support of the HiTEC® 3000 Fuel Additive Waiver Application (June 22, 1990)," at 7-9 (docket entry IV-F-5).

133/ Id. at 7-8.

134/ Transcript at pp. 31-32 (comments of Dewey Mark).

135/ Id. at p. 32.

136/ Indeed, in proposed amendments to the Clean Air Act (S-1630 and H.R. 3030), Congress is contemplating the establishment of minimum oxygen levels in gasoline in certain cities around the country which do not meet the ambient standard for CO.

In sum, the Additive would provide added flexibility to refiners as they struggle to meet specific gasoline composition requirements imposed by law in the coming years.

D. Use of the Additive Will Not Adversely Affect Compliance with Tighter Hydrocarbon Emission Standards Adopted in the Future.

At Ethyl's request, Systems Applications, Inc. ("SAI") conducted several statistical analyses of the 48-car test fleet data to determine whether use of the Additive would cause or contribute to the failure of emission control systems to meet more stringent, future emission standards. Based on this analysis, SAI concluded that the Additive would not cause or contribute to the failure of vehicles to meet future emission standards, including tighter hydrocarbon standards. In fact, use of the Additive would help in attaining more stringent NOx standards.[137/]

This conclusion would apply even if Congress or EPA chose to focus on the overall reactivity of HC emissions (as opposed to total HC emissions). The speciation testing conducted by Southwest Research, Inc. suggests that use of the Additive could actually make it easier to meet HC emission controls based on reactivity.[138/] Use of the Additive in three test fuels (a certification fuel, a commercial fuel, and a reformulated fuel) resulted in lower overall reactivity when compared to clear

137/ See Waiver Application, Appendix 11.

138/ California has proposed vehicle emission standards based on reactivity. See Appendix 1, Attachment 4.

fuels, even where the total HC emissions were slightly higher for the Additive-fueled vehicle.[139/] These reactivity calculations clearly show an additional, potential benefit associated with use of the Additive.

In addition, questions have been raised as to whether the small 0.02 gram per mile increase in HC emissions observed with use of the Additive in the test program could make it more difficult to meet future HC emission standards.[140/] This concern, however, is misplaced for at least two reasons. First, Ethyl's analysis shows that even this small HC increase is unlikely to occur in commercial operation as refiners displace aromatics with the Additive.[141/] Second, the slight HC emission increase exhibited in Ethyl's test program occurred on technology designed to meet existing emission standards. As the automobile manufacturers develop more effective methods to meet more stringent standards, such as increasing catalyst efficiency from 90 to 99 percent, any small increase in HC emissions will likely be reduced even further.

Indeed, this was precisely the effect of the shift from oxidation control technology to three-way catalyst technology, and other engine improvements, such as oxygen sensors, electronic fuel injection and computer technology. The CRC study completed

---

139/ See Appendix 1, Attachment 2.

140/ Letter to Mary T. Smith from G.E. Allardyce dated June 21, 1990 (docket entry IV-D-18).

141/ Waiver Application, Appendix 10, at pp. 3-6; see also supra note 33.

in 1978 concluded that use of the Additive caused an approximate 0.09 gpm increase in HC emissions after 50,000 miles of vehicle operation in cars using oxidation technology.[142] Today, using more effective technology, Ethyl's test program shows that use of the Additive will cause HC emissions to increase, at most, only about 0.018 gpm. If future technology exhibits a similar decrease in HC emissions, one could expect the effect of the Additive on HC emissions to be reduced about five times, falling to an almost imperceptible 0.004 gpm or lower. For all these reasons, the Agency should treat cautiously any speculative claims by the automobile industry that the very slight HC emission increase exhibited in Ethyl's test program will preclude the certification of future automobiles.

As a final note, Congressional action to date on amendments to the Act has made the nature of future emission standards much more clear for the next 20 years or so. As a result, generalized claims by the auto industry about hypothetical future action should be recognized for what it is -- idle speculation. Ethyl has shown, to the extent that it can be shown today, that use of the Additive will not cause or contribute to the failure of vehicles to meet future emission standards. Having made this showing, the auto industry must do more to support its potential concerns than simply speculate about the future.

---

[142] J.D. Benson, R.J. Campion, L.J. Painter, "Results of Coordinating Research Council MMT Field Test Program," SAE Technical Paper No. 790706 (1979).

V. CONCLUSION

Ethyl has presented information in this proceeding which shows that use of the Additive will not cause or contribute to the failure of emission control systems to meet applicable emission standards. This is the principal focus of § 211(f)(4) of the Clean Air Act, and to Ethyl's knowledge, its showing on this issue remains unchallenged.

Ethyl has also established that use of the Additive will further the overall goals of the Act, including protection of the public health. While a very limited number of commentators have asserted that use of the Additive would create potential public health concerns associated with an increase in environmental levels of manganese, not one of these commentators has presented credible evidence in support of his or her position. They have not challenged Ethyl's showing that use of the Additive would result in clear, positive health effects, nor have they presented convincing evidence upon which to reassess the many recent investigations completed by the United States and others which conclude that low level exposure to manganese does not create public health concerns.

Instead, they merely assert that Ethyl has not borne its burden of disproving their unfounded allegations. As noted above, however, this is not a burden imposed by the Act on fuel additive waiver applicants. Ethyl has presented a wealth of information upon which EPA can reasonably conclude, as it has in the past, that the public health is not endangered by low levels of manganese in the environment such as those that would occur with use of the Additive.

Having established that use of the Additive will further the specific goal embodied in § 211(f)(4) and the more general purposes of the Act, the Agency must approve this waiver application.

A-90-16
IV-D-58

BEFORE THE
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

IN RE APPLICATION FOR A FUEL	)
ADDITIVE WAIVER FILED BY	)
ETHYL CORPORATION UNDER	)
§ 211 (f) (4) OF THE CLEAN AIR	)
ACT	)

APPENDICES TO COMMENTS IN SUPPORT OF THE WAIVER APPLICATION FOR THE HiTEC 3000 PERFORMANCE ADDITIVE

VOLUME ONE

APPENDICES 1, 2, 3

of Counsel:

Hunton & Williams
2000 Pennsylvania Ave., N.W.
P.O. Box 19230
Washington, D.C. 20036
(202) 955-1500

Ray Wilkins, Jr.
Senior Vice President
Ethyl Corporation
P.O. Box 2189
Richmond, VA 23217

July 23, 1990

APPENDIX 1

Reactivity of Hydrocarbon Emissions

Recent studies of the role of hydrocarbon emissions from automobiles in ozone formation have begun to focus on the reactivity of the specific hydrocarbon molecules found in the emissions rather than the gross amount of hydrocarbons emitted. This is because some hydrocarbons are relatively inert as ozone precursors (methane and other saturated compounds) while others (such as ethylene, propylene, isoprene and butenes) are highly reactive and thus have a high potential for producing ozone in situations where the other necessary ozone precursors, NO_x and sunlight, are present.

In Appendix 4 of its waiver application, Ethyl reported hydrocarbon emission speciation results from two cars of the same model from its large fleet tests. One of the cars had been run for approximately 66000 miles on Howell EEE fuel containing 1/32 gm of manganese per gallon as HiTEC 3000, and the other had run approximately the same mileage on the same fuel without the HiTEC 3000. The hydrocarbon emissions histories for the two cars were reasonably comparable although above the standards in both cars.

The hydrocarbon speciation tests which were run on these two cars used three base fuels in sequence, first Howell EEE, second a commercial regular unleaded, and finally a "reformulated" commercial fuel containing low aromatic content (20%) and about 5% of the oxygenated product, methyl t-butyl ether (MTBE).

Each of these fuels were divided into two batches, and the batch used for the car which had been running on HiTEC 3000 was treated with 1/32 gm of manganese as HiTEC 3000. The batch used for the car which had been run on neat Howell EEE was treated with approximately 6% of xylenes. Thus the octanes of both batches of each fuel were approximately equal.

The results of the speciation studies were submitted in Appendix 4 of Ethyl's waiver request.

Since completion of the speciation testing, Ethyl has continued work in this area by analyzing the reactivity of the hydrocarbon emissions. To do this, Ethyl has used a table of reactivities developed by William P. L. Carter of the Air Pollution Research Center, University of California at Riverside. This table of reactivities is attached.(Attachment 1) The column in this table labelled "Max Ret", or Max Reactivity, is the set of reactivity data which Ethyl used to calculate the reactivity of speciated hydrocarbons from the data presented in Appendix 4 in the Waiver Application. Total reactivity is determined by multiplying the Max Reactivity number by the amount of each speciated hydrocarbon, and then summing the results. A comparison of the total hydrocarbon emissions and the calculated reactivity of these emissions is shown in Attachment 2.

In every test the reactivity of the hydrocarbon emissions from the car using fuel treated with HiTEC 3000 was considerably lower than the reactivity of the emissions from the car using the same fuel treated with xylenes. In the cases where the total hydrocarbon emissions were lower from the car using HiTEC 3000 fuel (an average of about 10 percent for both the Howell EEE fuel and the commercial unleaded fuel), reactivity was even lower, ranging from 19 to 31%, averaging 27% lower for the car using HiTEC 3000.

In the case of the reformulated fuel, the total hydrocarbon emissions were about the same for both cars. Reactivity, however, was lower by 21 - 25%,(averaging 23%) in the car using reformulated fuel to which HiTEC 3000 had been added.

Ethyl has had the results of these tests analyzed by a prominent consultant in this field, Mr. Fred Lurmann of Sonoma Technology, Inc. A summary of Mr. Lurmann's professional experience is provided in Attachment 3, and a copy of his analysis is provided as Attachment 4. Mr. Lurmann's analysis provides an enlightening discussion of the technical background and usefulness of the reactivity approach to the hydrocarbon - ozone relationship. Of particular note, Mr. Lurmann (who has also been briefed on the overall results of Ethyl's fleet tests) concludes with respect to HiTEC 3000 that "its widespread use would have beneficial effects on ambient ozone concentrations. Providing there are no significant safety or health concerns associated with its use, its benefits appear large enough to warrant approval of its current use and its serious consideration in the on-going evaluations of alternative fuels".

I. Leeper.

TACHMENT I

Ozone Reactivity Estimates for Individual VOC Species
Represented in the Detailed SAPRC Mechanism (Carter, 1990)
From:
Development of Ozone Reactivity Scales for Volatile Organic Compounds
by William P. L. Carter
Air Pollution Research Center
University of California
Riverside CA 92512
4/27/90
kOH = OH radical rate constnat, in ppm-1 min-1
Kin.R = kinetic reactivity
Mec.R = mechanistic reactivity
Rct/C = reactivity, moles O3/ moles carbon VOC
Rct/g = reactivity, grams O3/ grams VOC
MaxRct = maximum reactivity scale.
MaxO3 = maximum ozone reactivity scale
KR Code = kinetic reactivity derivation code. See paper.
MR Code = mechanistic reactivity derivation code. See paper.
UNC Code = chemical uncertainty code (1=least uncertain). See paper.

ARB using this 5/30/90 max reactivity case

max ozone case

1 of 3

VOC ID	VOC Description	kOH	Kin.R. MaxRct	Kin.R. MaxO3	Mec.R. MaxRct	Mec.R. MaxO3	Rct/C MaxRct	Rct/C MaxO3	Rct/g MaxRct	Rct/g MaxO3	Code KR	Code MR	Code UNC
CO	Carbon Monoxide	350	0.029	0.044	0.84	0.45	0.024	0.02	0.041	0.034	1	1	1
METHANE	Methane	13	0.001	0.001	3.4	1.6	0.0034	0.0025	0.0102	0.0074	1	2	2
ETHANE	Ethane	400	0.032	0.05	1.42	0.61	0.046	0.031	0.147	0.097	1	1	2
PROPANE	Propane	1800	0.137	0.21	0.74	0.34	0.101	0.071	0.33	0.23	1	2	2
N-C4	n-Butane	3800	0.26	0.38	0.73	0.34	0.19	0.128	0.64	0.42	1	1	1
N-C5	n-Pentane	5800	0.38	0.52	0.51	0.26	0.19	0.137	0.64	0.46	1	2	4
N-C6	n-Hexane	7900	0.48	0.63	0.38	0.21	0.18	0.131	0.61	0.44	1	2	4
N-C7	n-Heptane	9900	0.56	0.72	0.26	0.143	0.144	0.103	0.48	0.34	1	2	4
N-C8	n-Octane	12000	0.63	0.78	0.19	0.107	0.121	0.084	0.41	0.28	1	1	4
N-C9	n-Nonane	14000	0.68	0.83	0.127	0.074	0.087	0.062	0.29	0.21	1	2	4
N-C10	n-Decane	16000	0.73	0.87	0.1	0.059	0.073	0.051	0.25	0.17	1	2	5
N-C11	n-Undecane	18000	0.77	0.9	0.082	0.049	0.064	0.044	0.21	0.149	1	2	6
N-C12	n-Dodecane	20000	0.81	0.92	0.07	0.042	0.057	0.039	0.19	0.131	1	2	6
N-C13	n-Tridecane	22000	0.84	0.94	0.06	0.038	0.05	0.036	0.17	0.121	1	2	6
N-C14	n-Tetradecane	24000	0.86	0.96	0.053	0.034	0.046	0.032	0.16	0.11	1	2	6
N-C15	n-Pentadecane	26000	0.89	0.97	0.048	0.031	0.042	0.03	0.144	0.101	1	1	6
ISO-C4	Isobutane	3500	0.25	0.36	1.03	0.48	0.26	0.17	0.85	0.57	1	2	5
C4C5	Lumped C4-C5 Alkanes	4700	0.32	0.45	0.66	0.31	0.21	0.143	0.78	0.53	1	2	5
BR-C5	Branched C5 Alkanes	5900	0.38	0.53	0.69	0.34	0.26	0.18	0.88	0.59	1	2	5
ISO-C5	Iso-Pentane	5900	0.38	0.53	0.69	0.34	0.26	0.18	0.88	0.59	1	2	5
NEO-C5	Neopentane	1100	0.087	0.132	0.65	0.23	0.056	0.03	0.19	0.099	1	2	5
2-ME-C5	2-Methyl Pentane	7900	0.48	0.64	0.57	0.26	0.27	0.17	0.91	0.55	1	2	5
3-ME-C5	3-Methylpentane	8500	0.5	0.66	0.57	0.28	0.28	0.19	0.95	0.63	1	2	5
BR-C6	Branched C6 Alkanes	7900	0.48	0.64	0.57	0.26	0.27	0.17	0.91	0.55	1	2	5
23-DMB	2,3-Dimethyl Butane	8000	0.48	0.64	0.46	0.25	0.22	0.16	0.74	0.54	1	2	4
22-DMB	2,2-Dimethyl Butane	2700	0.2	0.29	0.62	0.27	0.123	0.079	0.41	0.27	1	2	5
C6PLUS	Lumped C6+ Alkanes	9000	0.52	0.68	0.39	0.2	0.2	0.134	0.7	0.46	1	2	5
24-DM-C5	2,4-Dimethyl Pentane	10000	0.56	0.72	0.57	0.25	0.32	0.18	1.07	0.61	1	2	5
3-ME-C6	3-Methyl Hexane	11000	0.58	0.74	0.44	0.21	0.25	0.16	0.85	0.53	1	2	5
4-ME-C6	4-Methyl Hexane	11000	0.58	0.74	0.44	0.21	0.25	0.16	0.85	0.53	1	2	5
BR-C7	Branched C7 Alkanes	11000	0.58	0.74	0.44	0.21	0.25	0.16	0.85	0.53	1	2	5
23-DM-C5	2,3-Dimethyl Pentane	11000	0.58	0.74	0.49	0.25	0.29	0.19	0.96	0.63	1	2	5
ISO-C8	Iso-Octane	6900	0.43	0.59	0.48	0.2	0.21	0.119	0.7	0.4	1	2	5
4-ME-C7	4-Methyl Heptane	13000	0.64	0.8	0.33	0.16	0.21	0.128	0.72	0.43	1	2	5
BR-C8	Branched C8 Alkanes	13000	0.64	0.8	0.33	0.16	0.21	0.128	0.72	0.43	1	2	5
BR-C9	Branched C9 Alkanes	15000	0.72	0.86	0.28	0.136	0.2	0.117	0.68	0.39	1	2	6
4-ET-C7	4-Ethyl Heptane	15000	0.72	0.86	0.28	0.136	0.2	0.117	0.68	0.39	1	2	6
BR-C10	Branched C10 Alkanes	17000	0.76	0.89	0.23	0.112	0.18	0.1	0.6	0.34	1	2	6
4-PR-C7	34-Propyl Heptane	17000	0.76	0.89	0.23	0.112	0.18	0.1	0.6	0.34	1	2	6
BR-C11	Branched C11 alkanes	21000	0.82	0.93	0.26	0.142	0.21	0.132	0.72	0.45	1	2	6
BR-C12	Branched C12 Alkanes	23000	0.85	0.95	0.26	0.141	0.22	0.134	0.75	0.45	1	2	6
BR-C13	Branched C13 Alkanes	25000	0.87	0.96	0.19	0.108	0.17	0.104	0.57	0.35	1	[illegible]	[illegible]

VOC ID	VOC Description	kOH	Kin.R. MaxRct	Kin.R. MaxO3	Mec.R. MaxRct	Mec.R. MaxO3	Rct/C MaxRct	Rct/C MaxO3	Rct/g MaxRct	Rct/g MaxO3	Code KR	Code MR	Code UNC
BR-C14	Branched C14 Alkanes	27000	0.89	0.97	0.147	0.087	0.131	0.084	0.44	0.29	1	2	6
BR-C15	Branched C15 Alkanes	29000	0.91	0.98	0.132	0.078	0.12	0.076	0.41	0.26	1	2	6
CYCC5	Cyclopentane	8200	0.49	0.65	0.95	0.45	0.47	0.29	1.6	1	1	2	5
ME-CYCC5	Methylcyclopentane	10000	0.57	0.74	0.87	0.43	0.5	0.32	1.7	1.08	1	2	5
CYC-C6	C6 Cycloalkanes	12000	0.64	0.79	0.38	0.18	0.25	0.143	0.84	0.49	1	2	5
CYCC6	Cyclohexane	12000	0.64	0.79	0.38	0.18	0.25	0.143	0.84	0.49	1	2	5
CYC-C7	C7 Cycloalkanes	15000	0.71	0.85	0.49	0.23	0.34	0.2	1.17	0.67	1	2	5
ME-CYCC6	Methylcyclohexane	15000	0.71	0.85	0.49	0.23	0.34	0.2	1.17	0.67	1	2	4
ET-CYCC6	Ethylcyclohexane	18000	0.77	0.9	0.52	0.25	0.4	0.22	1.36	0.76	1	2	5
CYC-C8	C8 Cycloalkanes	18000	0.77	0.9	0.52	0.25	0.4	0.22	1.36	0.76	1	2	6
CYC-C9	C9 Cycloalkanes	21000	0.81	0.93	0.57	0.28	0.47	0.26	1.6	0.89	1	2	6
CYC-C10	C10 Cycloalkanes	23000	0.85	0.95	0.45	0.23	0.38	0.22	1.31	0.74	1	2	6
CYC-C11	C11 Cycloalkanes	26000	0.88	0.96	0.41	0.21	0.36	0.2	1.23	0.7	1	2	6
CYC-C12	C12 Cycloalkanes	29000	0.91	0.98	0.39	0.2	0.35	0.2	1.2	0.68	1	2	6
CYC-C13	C13 Cycloalkanes	31000	0.92	0.98	0.3	0.16	0.27	0.15	0.94	0.52	1	2	6
CYC-C14	C14 Cycloalkanes	33000	0.93	0.99	0.28	0.138	0.26	0.136	0.88	0.47	1	2	6
CYC-C15	C15 Cycloalkanes	35000	0.94	0.99	0.26	0.131	0.25	0.13	0.85	0.44	1	2	6
ETHENE	Ethene	12000	0.67	0.81	2.3	0.95	1.6	0.77	5.3	2.6	2	1	1
PROPENE	Propene	38000	0.92	0.97	2.1	0.85	1.9	0.83	6.6	2.8	2	1	3
1-BUTENE	1-Butene	46000	0.95	0.98	1.9	0.72	1.8	0.7	6.1	2.4	2	1	3
1-PENTEN	1-Pentene	46000	0.95	0.98	1.31	0.49	1.24	0.48	4.2	1.6	2	1	5
3M-1-BUT	3-Methyl-1-Butene	46000	0.95	1	1.31	0.49	1.24	0.49	4.2	1.7	3	3	5
1-HEXENE	1-Hexene	54000	0.96	1	0.91	0.34	0.87	0.34	3	1.16	2	1	3
C6-OLE1	C6 Terminal Alkenes	54000	0.96	1	0.91	0.34	0.87	0.34	3	1.16	3	3	5
C7-OLE1	C7 Terminal Alkenes	54000	1	1	0.7	0.26	0.7	0.26	2.4	0.88	5	4	6
C8-OLE1	C8 Terminal Alkenes	54000	1	1	0.55	0.2	0.55	0.2	1.9	0.68	5	1	6
C9-OLE1	C9 Terminal Alkenes	54000	1	1	0.46	0.16	0.46	0.16	1.6	0.56	5	4	6
C10-OLE1	C10 Terminal Alkenes	54000	1	1	0.38	0.137	0.38	0.137	1.32	0.47	5	1	6
C11-OLE1	C11 Terminal Alkenes	54000	1	1	0.34	0.119	0.34	0.119	1.15	0.41	5	1	6
C12-OLE1	C12 Terminal Alkenes	54000	1	1	0.3	0.106	0.3	0.106	1.03	0.36	5	4	6
C13-OLE1	C13 Terminal Alkenes	54000	1	1	0.27	0.095	0.27	0.095	0.93	0.33	5	1	6
C14-OLE1	C14 Terminal Alkenes	54000	1	1	0.25	0.087	0.25	0.087	0.86	0.3	5	4	6
C15-OLE1	C15 Terminal Alkenes	54000	1	1	0.23	0.081	0.23	0.081	0.8	0.28	5	1	6
ISOBUTEN	Isobutene	75000	1	1	1.24	0.5	1.24	0.5	4.2	1.7	4	1	4
2M-1-BUT	2-Methyl-1-Butene	88000	1	1	1.09	0.45	1.09	0.45	3.7	1.5	4	1	5
T-2-BUTE	trans-2-Butene	92000	1	1	2.1	0.82	2.1	0.82	7.3	2.8	4	1	4
C-2-BUTE	cis-2-Butene	82000	1	1	2.1	0.82	2.1	0.82	7.3	2.8	3	3	4
2M-2-BUT	2-Methyl-2-Butene	130000	1	1	1.45	0.53	1.45	0.53	5	1.8	4	1	5
C5-OLE2	C5 Internal Alkenes	92000	1	1	1.8	0.67	1.8	0.67	6.2	2.3	4	1	5
23M2-BUT	2,3-Dimethyl-2-Butene	160000	1	1	1.07	0.36	1.07	0.36	3.7	1.22	4	1	5
C6-OLE2	C6 Internal Alkenes	92000	1	1	1.5	0.56	1.5	0.56	5.3	1.9	4	1	6
C7-OLE2	C7 Internal Alkenes	92000	1	1	1.27	0.46	1.27	0.46	4.4	1.6	5	4	6
C8-OLE2	C8 Internal Alkenes	92000	1	1	1.07	0.38	1.07	0.38	3.6	1.3	5	1	6
C9-OLE2	C9 Internal Alkenes	92000	1	1	0.93	0.33	0.93	0.33	3.2	1.13	5	4	6
C10-OLE2	C10 Internal Alkenes	92000	1	1	0.82	0.29	0.82	0.29	2.8	0.99	5	1	6
C11-OLE2	C11 Internal Alkenes	92000	1	1	0.73	0.26	0.73	0.26	2.5	0.89	5	1	6
C12-OLE2	C12 Internal Alkenes	92000	1	1	0.67	0.24	0.67	0.24	2.3	0.81	5	4	6
C13-OLE2	C13 Internal Alkenes	92000	1	1	0.61	0.22	0.61	0.22	2.1	0.74	5	1	6
C14-OLE2	C14 Internal Alkenes	92000	1	1	0.57	0.2	0.57	0.2	1.9	0.69	5	4	6
C15-OLE2	C15 Internal Alkenes	92000	1	1	0.53	0.19	0.53	0.19	1.8	0.64	5	1	6
13-BUTDE	1,3-Butadiene	97000	1	1	2.2	0.85	2.2	0.85	7.7	3	4	1	6
ISOPRENE	Isoprene	150000	1	1	1.8	0.7	1.8	0.7	6.5	2.5	4	1	4
CYC-PNTE	Cyclopentene	97000	1	1	1.13	0.4	1.13	0.4	4	1.41	4	1	6
CYC-HEXE	Cyclohexene	98000	1	1	0.94	0.36	0.94	0.36	3.3	1.27	4	1	6
A-PINENE	a-Pinene	78000	1	1	0.55	0.21	0.55	0.21	1.9	0.74	5	1	4
B-PINENE	b-Pinene	110000	1	1	0.55	0.21	0.55	0.21	1.9	0.74	5	3	6
BENZENE	Benzene	1900	0.143	0.21	0.54	0.111	0.077	0.024	0.28	0.088	1	1	3
TOLUENE	Toluene	8700	0.51	0.67	1	0.17	0.51	0.111	1.9	0.41	1	1	3
C2-BENZ	Ethyl Benzene	10000	0.57	0.74	0.88	0.145	0.5	0.107	1.8	0.39	1	3	5
N-C3-BEN	n-Propyl Benzene	8800	0.51	0.68	0.78	0.129	0.4	0.087	1.44	0.31	1	3	5
I-C3-BEN	Isopropyl Benzene	9500	0.54	0.71	0.78	0.129	0.42	0.091	1.5	0.33	1	3	5
S-C4-BEN	s-Butyl Benzene	8800	0.51	0.68	0.7	0.116	0.36	0.078	1.29	0.28	1	3	5
C10-BEN1	C10 Monoalkyl Benzenes	8700	0.51	0.67	0.7	0.116	0.36	0.078	1.28	0.28	1	3	6
C11-BEN1	C11 Monoalkyl Benzenes	8700	0.51	0.67	0.64	0.106	0.32	0.071	1.16	0.25	1	3	6

2 of 3

VOC ID	VOC Description	kOH	Kin.R. MaxRct	Kin.R. MaxO3	Mec.R. MaxRct	Mec.R. MaxO3	Rct/C MaxRct	Rct/C MaxO3	Rct/g MaxRct	Rct/g MaxO3	Code KR	Code MR	Code UNC
C12-BEN1	C12 Monoalkyl Benzenes	8700	0.51	0.67	0.58	0.097	0.3	0.065	1.06	0.23	1	3	6
M-XYLENE	m-Xylene	35000	0.94	0.99	1.8	0.52	1.7	0.51	6	1.9	1	1	3
O-XYLENE	o-Xylene	20000	0.81	0.92	1.8	0.52	1.42	0.48	5.2	1.7	1	3	3
P-XYLENE	p-Xylene	21000	0.82	0.93	1.8	0.52	1.45	0.48	5.2	1.8	1	3	5
C9-BEN2	C9 Dialkyl Benzenes	35000	0.94	0.99	1.6	0.46	1.48	0.46	5.3	1.6	1	3	6
C10-BEN2	C10 Dialkyl Benzenes	35000	0.94	0.99	1.41	0.42	1.33	0.41	4.8	1.47	1	3	6
C11-BEN2	C11 Dialkyl Benzenes	35000	0.94	0.99	1.28	0.38	1.21	0.37	4.3	1.33	1	3	6
C12-BEN2	C12 Dialkyl Benzenes	35000	0.94	0.99	1.18	0.35	1.11	0.34	3.9	1.22	1	3	6
135-TMB	1,3,5-Trimethyl Benzene	84000	1	1	2.1	0.67	2.1	0.67	7.5	2.4	1	1	3
123-TMB	1,2,3-Trimethyl Benzene	48000	0.98	1	2.1	0.67	2.1	0.66	7.4	2.4	1	3	5
124-TMB	1,2,4-Trimethyl Benzene	48000	0.98	1	2.1	0.67	2	0.66	7.4	2.4	1	3	5
C10-BEN3	C10 Trialkyl Benzenes	84000	1	1	1.9	0.6	1.9	0.6	6.7	2.1	1	3	6
C11-BEN3	C11 Trialkyl Benzenes	84000	1	1	1.7	0.54	1.7	0.54	6.1	1.9	1	3	6
C12-BEN3	C12 Trialkyl Benzenes	84000	1	1	1.6	0.5	1.6	0.5	5.6	1.8	1	3	6
TETRALIN	Tetralin	50000	0.98	1	0.2	0.03	0.2	0.03	0.73	0.109	1	1	4
NAPHTHAL	Naphthalene	32000	0.93	0.98	0.25	0.012	0.23	0.0118	0.87	0.044	1	1	4
ME-NAPH	Methyl Naphthalenes	76000	1	1	0.64	0.145	0.63	0.145	2.4	0.54	1	1	6
23-DMN	2,3-Dimethyl Naphthalene	110000	1	1	1.01	0.27	1.01	0.27	3.7	1	1	1	4
ACETYLEN	Acetylene	1100	0.09	0.137	1.11	0.53	0.099	0.073	0.37	0.27	1	2	4
MEOH	Methanol	1400	0.107	0.16	2.5	0.93	0.27	0.15	0.4	0.22	1	1	1
ETOH	Ethanol	4800	0.33	0.46	1.04	0.36	0.34	0.17	0.7	0.34	1	1	2
N-C3-OH	n-Propyl Alcohol	7800	0.47	0.63	1.17	0.4	0.55	0.25	1.33	0.6	1	2	5
I-C3-OH	Isopropyl Alcohol	7600	0.47	0.62	0.33	0.17	0.16	0.105	0.37	0.25	1	2	5
I-C4-OH	Isobutyl Alcohol	14000	0.68	0.83	0.41	0.19	0.28	0.16	0.72	0.41	1	2	5
N-C4-OH	n-Butyl Alcohol	12000	0.63	0.79	1	0.37	0.63	0.29	1.6	0.75	1	2	5
T-C4-OH	t-Butyl Alcohol	1700	0.127	0.19	0.89	0.4	0.113	0.077	0.29	0.2	1	2	5
ET-GLYCL	Ethylene Glycol	11000	0.6	0.76	1.21	0.48	0.73	0.37	1.13	0.57	1	2	5
PR-GLYCL	Propylene Glycol	18000	0.76	0.9	0.63	0.25	0.48	0.23	0.92	0.43	1	2	5
FORMALD	Formaldehyde	14000	0.94	0.98	4.2	1.3	3.9	1.26	6.2	2	2	1	1
ACETALD	Acetaldehyde	23000	0.83	0.92	2.1	0.77	1.7	0.7	3.8	1.5	2	1	3
PROPALD	Propionaldehyde	29000	0.91	0.95	2	0.7	1.8	0.66	4.6	1.6	2	1	4
ACETONE	Acetone	340	0.044	0.058	3.6	0.95	0.16	0.055	0.39	0.137	2	1	4
MEK	C4 Ketones	1700	0.16	0.22	1.8	0.53	0.29	0.117	0.76	0.31	2	1	4
BENZALD	Benzaldehyde	19000	0.84	0.95	-0.2	-0.31	-0.17	-0.3	-0.54	-0.93	2	1	4
PHENOL	Phenol	39000	1	1	0.26	-0.17	0.26	-0.17	0.79	-0.54	4	1	5
CRESOL	Cresols	62000	1	1	0.51	-0.23	0.51	-0.23	1.6	-0.72	4	1	4

1.9 .6.8
1.6 .89

7.4 1.3 4 3
2.4 .3 = 1.3

4.8 1.57
1.2 .3
3.0 .9

5.2 1.7
.7 .4
2.8 1.0

1.3 .3 = .8
.3 .2 .2

.28 4.8
1.5

Attachment 2

Comparison of Speciated Emissions from Ethyl Test Cars F-3 and F-5

Note: FTP-HC is Federal Test Procedure Hydrocarbons in Mgm/mile Reactivity is the sum of each speciated hydrocarbon times its reactivity. Mileages are distance operated on each fuel at time of tests.

Base Fuel	Octane Enhancer	500 Miles		1,000 miles	
		FTP-HC	Reactivity	FTP-HC	Reactivity
Howell EEE	HiTEC 3000	475	549	550	662
	Xylenes	562	794	574	933
	Difference (Xylene minus HiTEC)	87	245	24	271
	Percent Improvement with HiTEC	15.5	31	4	29
		1000 miles		2000 miles	
	HiTEC 3000	510	705	478	597
Commercial Regular Unleaded	Xylenes	540	870	568	844
	Difference (Xylene mimus HiTEC)	30	165	90	247
	Percent Improvement with HiTEC	5.5	19	15.8	29
		1000 miles		2000 miles	
	HiTEC 3000	530	600	605	689
Reformulated	Xylenes	536	796	590	876
	Difference (Xylene minus HiTEC)	6	196	(15)	187
	Percent Improvement with HiTEC	1	25	(2.5)	21

99table

ATTACHMENT 3

RESUME
FRED W. LURMANN
Senior Scientist

Sonoma Technology Inc.

5510 Skylane Blvd., Suite 101
Santa Rosa, CA 95403-1083
707/527-9372

Educational Background

B.S. Mechanical Engineering (1971), Univ. of Calif., Santa Barbara
M.S. Mechanical and Environmental Engineering (1975), University of California, Santa Barbara

---

Professional Experience

Mr. Lurmann joined STI as a senior scientist in July 1989. At STI, he manages total human exposure modeling, photochemical modeling and aerometric data analysis studies. Currently he is continuing the development of the Regional Human Exposure (REHEX) model, directing the analysis of hydrocarbon and carbonyl data collected in the Southern California Air Quality Study (SCAQS), updating the photochemical reaction mechanism used in the Urban Airshed Model, and investigating alternative methods for evaluation of photochemical air quality models.

Prior to joining STI, Mr. Lurmann was a private air quality consultant for three years and a senior scientist/program manager with Environmental Research & Technology, Inc. for ten years. Mr. Lurmann has been a leader in the development and evaluation of a number of Eulerian and Lagrangian air quality models, including the ELSTAR model, the PLMSTAR model, the MESOPUFF-II model, the FOGCHEM model, and the ADOM model. He has directed numerous studies on the development of atmospheric chemical mechanisms for VOC/NO_x/SO_2 mixtures, including programs for anthropogenic and biogenic VOCs, and programs to evaluate mechanisms using environmental chamber data. He has developed a number of atmospheric models to assess the interaction of trace gases and aerosols with clouds and precipitation. He has also developed a number of parameterized chemical mechanisms for the formation of secondary PM_{10} in urban and rural areas.

Mr. Lurmann has extensive experience applying photochemical and acid deposition models for assessment of emissions - air quality relationships. He has directed studies to evaluate complex models and regional control strategies, to apply models to aid in the design of field experiments, and to assess compliance of new and modified facilities with air quality standards. Mr. Lurmann's modeling and data analysis studies have provided extensive experience in the management of large aerometric and emission data bases.

As part of interdisciplinary studies to assess the economic value air quality improvements in the Los Angeles Basin, Mr. Lurmann has developed a comprehensive regional human exposure model and data base. The model is designed to estimate long-term frequency distributions of air pollution exposure and dosage for residents of large metropolitan areas.

Memberships

Air and Waste Management Association
American Chemical Society

Technical Committees

Member of the California Air Resources Board's Modeling Advisory Committee, appointed 1988.

Journal Articles

Carter, W. P. L. and Lurmann F. W. (1990) Evaluation of a Detailed Gas Phase Atmospheric Reaction Mechanism Using Environmental Chamber Data. Atmos. Environ. (in press).

Lurmann F. W., Lloyd A. C. and Atkinson R. (1986) A Chemical Mechanism For Use in Long-Range Transport/Acid Deposition Computer Modeling. J. of Geophysical Research 91, No. D10, pp. 10,905-10,936.

Lurmann F. W., Nitta B., Ganesan K. and Lloyd A. C. (1984) Modeling Potential Impacts from Natural Hydrocarbons, Part III: Ozone Modeling in Tampa/ St. Petersburg, FL. Atmos. Environ. 18, no. 6, p. 1133-1143.

Lurmann F. W., Nitta B. and LLoyd A. C. (1983) Modeling Potential Impacts from Natural Hydrocarbons, Part II: Hypothetical Biogenic HC Modeling. Atmos. Environ. 17, no. 10, pp. 1951-1963.

Lloyd A. C., Atkinson R. and Lurmann F. W. (1983) Modeling Potential Impacts from Natural Hydrocarbons, Part I: Development and Testing of a Chemical Mechanism for Photooxidation of Isoprene and Alpha-Pinene. Atmos. Environ. 17, No. 10, pp. 1931-1950.

Meeting Presentations

Lurmann F. W., Winer A. M. and Colome S. D. (1989) Development and Application of a New Regional Human Exposure (REHEX) Model. Paper presented at the Total Exposure Assessment Methodology Conference, Las Vegas, NV.

Lurmann F. W. and Carter W. P. L. (1989) A Performance Evaluation of the SAPRC and RADM Chemical Reaction Mechanisms. Paper No. 89-42B.5 presented at the 82nd Meeting of the Air & Waste Management Association, AWMA, Pittsburgh, PA.

Lurmann F. W., Coyner L., Winer A. M., and Colume S. (1989) Development of a New Regional Human Exposure (REHEX) Model and Its Application to the California South Coast Air Basin. Paper No. 89-27.5 presented at the 82nd Meeting of the Air & Waste Management Association, AWMA, Pittsburgh, PA.

Lurmann F. W. (1988) A Review of PM_{10} Air Quality Models. In Receptor Models in Air Resource Management, APCA, Pittsburgh, PA.

Lurmann F. W. (1987) Evaluation of a Detailed Photochemical Reaction Mechanism. In Proceeding of APCA Specialty Conference on the Scientific and Technical Issues Facing Post 1987 Ozone Control Strategies. APCA, Pittsburgh, PA.

Lurmann F. W. (1987) Evaluation of a Surrogate Species Chemical Reaction Mechanism. In Proceeding of the North American Oxidant Symposium, Quebec City, Quebec, Canada, February 24-27, 1987.

Lurmann F. W., Young J. R. and Hidy G. M. (1986) A Study of Cloudwater Acidity Downwind of Urban and Power Plant Sources. In Chemistry of Multiphase Atmospheric Systems, W. Jaeschke, ED., Springer-Verlag, Berlin.

Karamchandani P. K. and Lurmann F. W. (1986) A Simplified Stratiform Cloud-Wet Chemistry Model for Regional Modeling. Fifth Joint Conference on Application of Air Pollution Meteorology. Nov. 18-21, Chapel Hill, NC. American Meteorological Society, Boston, MA.

Heisler S. L., Young J. and Lurmann F. W. (1985) The EPRI National Emissions Inventory. Paper 85-4.3 presented at the 78th Annual Meeting of the Air Pollution Control Association, Pittsburgh, PA.

Lurmann F. W., Nitta B., Ganesan K. and Lloyd A. C. (1984) The Impacts of Natural Hydrocarbon Emissions on Ozone in Tampa/St.Petersburg, Florida. In Environmental Impacts of Natural Emissions, V.P. Aneja Ed., APCA, Pittsburgh, PA.

Lurmann F. W., Godden D. A. and Lloyd A. C. (1982) The Development and Testing of the PLMSTAR Reactive Plume Model. Third Joint Conference on Applications of Air Pollution Meteorology, January 12-15, San Antonio, TX. American Meteorological Society, Boston, MA.

Lloyd A. C., Lurmann, F. W., Godden D. and Hutchins J. (1979) Development, Testing and Possible Applications of ELSTAR. In Ozone/Oxidants: Interaction with the Total Environment. APCA, Pittsburgh, PA.

Formal Reports

Lurmann, F. W. (1990) User's Guide to the Regional Human Exposure Model. Draft Report to the South Coast Air Quality Management District. Sonoma Technology Inc., Santa Rosa, CA, STI Report No. 99130-1003.

Lurmann, F. W. (1990) Application of the Regional Human Exposure Model Using Urban Airshed Model Outputs. Report to the South Coast Air Quality Management District. Sonoma Technology Inc., Santa Rosa, CA, STI Report No. 99130-1004.

Lurmann F. W., Winer A. M., Poe M. and Durbin T. (1989) Sensitivity Analysis of the Regional Human Exposure (REHEX) Model. Final Report to U.S. Environmental Protection Agency. Sonoma Technology Inc., Santa Rosa, CA, STI Report No. 99170-992-FR.

Lurmann, F. W. (1989) VOC Monitoring Plan for the San Joaquin Valley Air Quality Study, Sonoma Technology Inc., Santa Rosa, CA.

Winer A. M., Lurmann F. W., Coyner L. A., Colome S. D. and Poe M. P. (1989) Characterization of Air Pollutant Exposures in the California South Coast Air Basin: Application of a New Regional Human Exposure (REHEX) Model. University of California, Riverside Report to the South Coast Air Quality Management District, Contract No. TSA 106-01-88.

Lurmann F. W., Winer A. M., Poe M. and Durbin T. (1989) Sensitivity Analysis of the Regional Human Exposure (REHEX) Model. Final Report to U.S. Environmental Protection Agency. Prepared by Sonoma Technology, Inc., STI No. 99170-992-FR.

Carter W. P. L. and Luramnn F. W. (1989) Evaluation of the RADM Gas-Phase Chemical Mechanism. University of California, Riverside Report to U.S. EPA, Agreement CR-814558-01, Riverside, CA.

Stockwell W. R. and Lurman F. W. (1989) Intercomparison of the ADOM and RADM Gas-Phase Chemical Mechanisms. State University of New York, Albany, NY. Report to the Electric Power Research Institute.

Lurmann F. W. (1989) The Effects of Anthropogenic Hydrocarbon Emission Reductions in Urban Areas with High Biogenic Hydrocarbon Emission Rates: Tampa/St. Petersburg Case Study. Lurmann & Associates, Santa Barbara, CA. Report P137-1 to the U.S. Environmental Protection Agency.

Lurmann F. W., Watson J., Countess R. and Pratsinis S. (1988) A Review of PM_{10} Air Quality Issues in the South Coast Air Basin. ERT No. 6200-006., ERT, Camarillo, CA.

Young J. R. and Lurmann F. W. (1988) Proceedings of the CRC Methanol Workshop. ERT Inc., Camarillo, CA. Final Report to the Coordinating Research Council.

Lurmann F. W., Collins J. and Coyner L. (1988) Development of a Chemical Transformation Submodel for Annual PM_{10} Dispersion Modeling. P-6190-003, ENSR, Camarillo, CA. Final report to the South Coast Air Quality Management District.

Kuntasal G. and Lurmann F. W. (1988) Development of a Photochemical Mechanism for Long-Term Calculations. 2860-002-101, ERT Inc., Newbury Park, CA. Final Report to the Freie Universitat Berlin.

Lurmann F. W., Carter W. L. P. and Coyner L. A. (1987) A Surrogate Species Chemical Reaction Mechanism for Urban-scale Air Quality Simulation Models. EPA/600/3-87/014. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Atkinson R., Jeffries H., Whitten G. and Lurmann F. W. (1987) Workshop on Evaluation/Documentation of Chemical Mechanisms. EPA/600/9-87/024, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Lurmann F. W. and Karamchandani P. K. (1987) An Updated Gas-Phase Chemical Mechanism with Chlorine Chemistry for the TADAP Regional Model. P-E142-201, ERT Inc., Newbury Park, CA. Final Report to Freie Universitat Berlin.

Carter W. P. L., Luramann F. W., Atkinson R. and Lloyd A. C. (1986) Development and Testing of a Surrogate Species Chemical Mechanism. EPA/600/3-86/031, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Lurmann F. W., Lloyd A. C. and Atkinson R. (1986) Suggested Gas-Phase Species Measurements for the Southern California Air Quality Study. P-E124-001, ERT Inc., Newbury Park, CA. Final Report to the Coordinating Research Council.

Blumenthal D. L., Smith T. B., Lehrman D. E., Alexander N. L., Lurmann F. W. and Godden D. A. (1986) Analysis of aerometric and Meteorological Data for the Ventura County Region. 90094-511-FR, Sonoma Technology Inc., Santa Rosa, CA. Final Report to the Western Oil & Gas Association.

Karamchandani P. and Lurmann F. W. (1986) Potential Approaches for Modeling Acid Deposition in California. P-D578-401, ERT Inc., Newbury Park, CA. Final Report to Southern California Edison Company.

Young J. R., Collins J., Coyner L. and Lurmann F. W. (1986) Analysis of the SCE Precipitation Chemistry Data Base for Southern California. P-D578-300, ERT Inc., Newbury Park, CA. Final Report to Southern California Edison Company.

Karamchandani P., Lurmann F. W. and Venkatram A. (1986) Development of a Model for the Transport and Deposition of Acidifying Pollutants (TADAP). P-B980-102, ERT Inc.,Newbury Park, CA. Final Report to the Umweltbudesamt, West Germany.

Scire J. S., Venkatram A., Lurmann F. W. and Yamartino R. (1985) Summary of Recent Sensitivity Analyses with the ADOM/TADAP Prototype Model. P-D205-280, Environmental Research & Technology Inc., Concord, MA. Final Report to the Ontario Ministry of the Environment.

Lurmann F. W. (1985) Analysis of the Air Quality Impacts of Exploratory Drilling Operations on OCS Lease P-0504 in the Santa Maria Basin. Environmental Research & Technology Inc., Newbury Park, CA. Final Report to Atlantic Richfield.

Lurmann F. W. (1985) Analysis of the Ozone Impacts of Exploratory Drilling Operations on OCS Lease P-0505 in the Santa Maria Basin. ERT Inc., Newbury Park, CA. Final Report to Gulf Production Company.

Lurmann F. W., Godden D. A. and Collins H. M. (1985) User's Guide to the PLMSTAR Air Quality Simulation Model. M-2206-100, ERT Inc., Newbury Park, CA.

Lurmann F. W., Young J. R. and Lloyd A. C. (1985) An Evaluation of the Role of Hydrocarbons in the Formation of Strong Acids in the Atmosphere. P-D343-001, ERT Inc., Newbury Park, CA. Final Report to the American Petroleum Institute.

Karamchandani P., Lurmann F. W. and Venkatram A. (1985) Acid Deposition and Oxidant Model (ADOM) Development Program - Volume 8: Central Operator Design. P-B866-450, Environmental Research & Technology Inc., Westlake Village, CA. Final Report to the Ontario Ministry of the Environment.

Lurmann F. W., Lloyd A. C. and Atkinson R. (1984) Acid Deposition and Oxidant

15/15

Model (ADOM) Development Program - Volume 6: Gas-Phase Chemistry. P-B980-530, ERT Inc., Westlake Village, CA. Final Report to the Ontario Ministry of the Environment.

Young J. R. and Lurmann F. W. (1984) Acid Deposition and Oxidant Model (ADOM) Development Program - Volume 7: Aqueous-Phase Chemistry. P-B980-535, Environmental Research & Technology Inc., Westlake Village, CA. Final Report to the Ontario Ministry of the Environment.

Scire J. S., Lurmann F. W., Bass A. and Hana S. R. (1984) Development of the MESOPUFF II Dispersion Model. EPA Contract No. 68-02-3733. Environmental Research & Technology Inc., Concord, MA. Final Report to U.S. EPA.

Young J. R, Lurmann F. W. and Godden D.A. (1983) The Role of Mobile Source Emissions in the Fogwater Chemistry of the Los Angeles Basin. P-B542-000, Environmental Research & Technology Inc., Westlake Village, CA. Final Report to the Motor Vehicles Manufacturer's Association.

Godden D. A. and Lurmann F. W. (1983) Development of the PLMSTAR Model and Its Application to Ozone Episode Conditions in the South Coast Air Basin. P-A702-200, Environmental Research & Technology Inc., Westlake Village, CA. Final Report to Southern California Edison Company.

Grosjean D. A., Countess R., Fung K., Lurmann F. W. and Lloyd A. C. (1982) The Los Angeles Captive Air Study. P-B764-300, Environmental Research & Technology Inc., Westlake Village, CA. Final Report to the Coordinating Research Council.

Venkatram A., Lurmann F. W. and Yamartino R. (1982) Models for Long Range Transport and Deposition of Atmospheric Pollutants -Phase I: Modeling System Design. ERT Inc., Concord, MA. Final Report to Ontario Ministry of the Environ.

Lloyd A. C., Lurmann F. W., Godden D. A., Hutchins J. F., Eschenroeder A. Q. and Nordsieck R. A. (1979) Development of the ELSTAR Photochemical Air Quality Simulation Model and Its Evaluation Relative to the LARPP Data Base. P-5287-500, Environmental Research & Technology Inc., Westlake Village, CA. Final Report to the Coordinating Research Council.

ATTACHMENT 4

Sonoma Technology Inc.

5510 Skylane Blvd., Suite 101
Santa Rosa, CA 95403-1083
707 / 527-9372

July 12, 1990

STI Ref. No. 90000

Mr. T.A. Leeper
Ethyl Chemicals Group
Ethyl Tower
451 Florida Boulevard
Baton Rouge, LA 70801

Subject: Evaluation of the Photochemical Reactivity of Emissions from Vehicle Using Fuels with the HiTEC 3000 Additive

Dear Mr. Leeper:

Per your request, I have reviewed the speciated emissions data and reactivity calculations for Ethyl Corporation's tests of vehicles operating on fuels with and without the HITEC 3000 gasoline additive. These data includes tests of vehicles operating on the following six fuels:

- Howell EEE fuel with 0.03125 gm/gal of manganese as HiTEC 3000;
- Howell EEE fuel with additional xylenes to match the octane of the Howell EEE fuel with HiTEC 3000;
- A commercial fuel with 0.03125 gm/gal of manganese as HiTEC 3000;
- A commercial fuel with additional xylenes to match the octane of the commercial fuel with HiTEC 3000;
- A reformulated fuel with 0.03125 gm/gal of manganese as HiTEC 3000; and
- A reformulated fuel with additional xylenes to match the octane of the reformulated fuel with HiTEC 3000.

One vehicle (F-3) was run solely on the HiTEC 3000 fuels, while a second vehicle (F-5) was run on the "additional xylene" fuels. Both vehicles had between 67K and 70K miles at the time of testing.

As you know, the FTP total hydrocarbon exhaust emissions from the vehicle operating on Howell EEE and the commercial fuel with HiTEC 3000 were about 10% lower than those of the vehicle operating on these fuels with additional xylenes. The total hydrocarbon emissions from the two reformulated fuels were about the same. The NO_x and CO emissions were substantially lower (30-35%) in all tests of the vehicle operating on the HiTEC 3000 fuels.

In addition, there were important differences in the composition of the emitted hydrocarbons which have implications for their photochemical reactivity with respect to ozone formation in the atmosphere. The exhaust from the vehicle fueled with all three fuels containing manganese had smaller amounts of the most reactive compounds (olefins, higher aromatics, and oxygenates) and larger amounts of the less reactive alkanes.

The photochemical reactivity of organic compounds is difficult to assess for a number of reasons. First, the ozone formation potential of a compound depends not only on the rate at which it reacts in the atmosphere (i.e., its kinetic reactivity), but also on the reactivity of its photo-oxidation products (i.e., its mechanistic reactivity). The kinetic reactivity of most compounds present in automobile exhaust are known from laboratory data. The mechanistic reactivities are less certain. A second factor which complicates the assessment of reactivity is that the amount of ozone formed from a given amount of organic species depends on the chemical and meteorological conditions of the environment in which it reacts. The ozone formation depends on the concentrations of NO_x, ozone, and other organic species and on the temperature and solar radiation intensity. The most important environmental factor governing reactivity is the availability of NO_x. In general, organic compounds have a large effect on ozone formation under conditions with relatively high NO_x and, correspondingly, low ratios of volatile organic compounds (VOC) to NO_x. It is under these conditions that different organic species exhibit substantially different ozone formation potentials. Under low NO_x conditions and, correspondingly, high VOC to NO_x ratios organic compounds exhibit low reactivity because ozone formation is controlled by the availability of NO_x rather than the rate of free radical generation by the organic species. That is, when there is an excess of organic species relative to NO_x the reactivity differences between organic species are small and unimportant.

With respect to ozone control strategies, conditions in many urban areas in the United States are such that reductions in automotive emissions reactivity will reduce the rate of ozone formation and may reduce peak ozone levels. The effects of automotive reactivity reductions on rural ozone and on long range transport of ozone will probably be insignificant.

Notwithstanding the difficulties inherent in reactivity assessments, a number of researchers have developed relative reactivity scales for organic species. The most elementary scale is one based solely on kinetic reactivity (reactivity ranking based on OH rate constants). This scale suffers from the obvious short-comings of ignoring mechanistic reactivity and the effects of environmental factors. Carter and Atkinson (1989) developed the concept of incremental reactivity where in the reactivity of a compound is measured by its incremental effect on ozone production when a small amount is added to a typical mixture of organic species and NO_x. This concept corresponds more closely to the real world of air quality management where control measures which make small changes emissions and VOC composition are implemented. A detailed photochemical reaction mechanism is operated for a range of environmental scenarios to estimate the incremental reactivity of each organic compound. Using this modeling approach, Carter (1990) has developed the maximum reactivity scale and the maximum ozone reactivity scale. The maximum reactivity scale ranks reactivity under the relatively low VOC/NO_x conditions where organic compounds have the most effect on the rate of ozone formation. The maximum ozone reactivity scale ranks reactivity under the moderate VOC/NO_x conditions where ozone formation is most efficient. Carter has recommended the use of the maximum reactivity scale for regulatory use in California because of its robustness and the fact that it measures reactivity under the conditions where reactivity is most important. I concur with this recommendation. Furthermore, the California Air Resources Board has proposed vehicle emission standards that use this scale for reactivity credits.

Application of Carter's maximum reactivity factors (expressed as grams ozone formed per gram organic compound emitted) to the speciated emissions from Ethyl Corporations vehicle tests gives the follow results:

Base Fuel	With HiTEC 3000	With Additional Xylenes
Howell EEE:		
With CO	.60	.86
W/o CO	.55	.77
Commercial:		
With CO	.65	.86
W/o CO	.59	.76
Reformulated:		
With CO	.64	.84
W/o CO	.58	.74

The total reactivity is about 25% lower in the vehicle using the HiTEC 3000 additive in place of xylenes. The lowering of the reactivity appears to be independent of the base fuel composition. The relative reduction in reactivity is slightly greater when CO is included in the total reactivity sum (26% versus 24% on the average). These reactivities include the effects of lower total hydrocarbon emissions for vehicle using HiTEC 3000. However, even when this effect is discounted, the average reactivity reduction (without CO) is 19% for the car using HiTEC 3000.

Some regulators argue that CO should not be included in reactivity totals because its emissions are covered by a different standard than organics. From a technical perspective, lowering CO lowers the reactivity. It is important to note that, unlike some oxygenated fuel blends where the largest effect on reactivity comes from reductions in CO emissions, the majority of the reduction in reactivity of the HiTEC 3000 fuels come from lower emissions of the highly reactive olefins, higher aromatics and aldehydes.

In summary, you have used the best available reactivity scale for assessing the effect of this additive on reactivity. Based on the results of this two car test, the additive appears to substantially reduce the photochemical reactivity for all of the base fuels. Its lower reactivity, combined with the large reductions in NO_x and CO emissions, suggests its widespread use would have beneficial effects on ambient ozone concentrations. Providing there are no significant safety or health concerns associated with its use, its benefits appear large enough to warrant approval of its current use and its serious consideration in the on-going evaluations of alternative fuels.

Please do not hesitate to contact me if you have any questions regarding this matter.

Sincerely,

Fred Lurmann

Fred Lurmann
Senior Scientist

FL/ng

References:

Carter, W.P.L. and R. Atkinson (1989), A Computer Modeling Study of Incremental Hydrocarbon Reactivity. Environmental Science and Technology.

Carter, W.P.L. (1990), Development of Ozone Reactivity Scales for volatile Organic Compounds. Atmospheric Environment (in press).